ER 60-9692/a

card

John J. Hartford, M. D.
STAT [redacted]

Dear Dr. Hartford:

Mr. Dulles asked me to thank you very much for your letter of 15 December and for the book, You Can Trust the Communists by Dr. Fred Schwarz. It was thoughtful of you to make the publication available to him.

I am enclosing for your information a copy of the talk that Mr. Dulles made before the Veterans of Foreign Wars, the condensation of which you mentioned. Your expression of support is indeed appreciated.

With kindest regards,

Sincerely,

Signed

[redacted] STAT

Assistant to the Director

Enclosure
O/DCI/SJGrogan:abk(20 Dec. 60)
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Orig. - Addressee w/encl.
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ER 60-9692/a

John J. Hartford, M.D.

STAT [redacted]

Dear Doctor Hartford:

I want to thank you for your interesting letter of 15 December 1960 and for the book, You Can't Trust The Communists, by Dr. Fred Schwarz which accompanied your letter.

I was familiar with Dr. Schwarz' book, having read it sometime ago. For that reason I am returning it to you so that you may consider giving it to someone else who may be interested.

I am enclosing a copy of my address of 22 August 1960 in Detroit to the Veterans of Foreign Wars, the condensation of which you referred to in your letter. Again, thank you for your support.

Sincerely,

Allen W. Dulles
Director

SJG

Enc.

O/DCI/SJGrogan:abk(20 Dec 60)
Distribution:
Orig - Add w/book
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2 - SJGrogan

STAT

December 15, 1960.

Allen W. Dulles, Director,
Central Intelligence Agency,
Washington, D.C.

Dear Mr. Dulles:

In the last issue of Reader's Digest is a condensation of your address delivered in Detroit before a convention of the Veterans of Foreign Wars August 22nd last. Your recommendation, that people must be sufficiently educated in all ramifications of the Bolshevik movement, its intrigues and historical background and in its purposes and programs to contribute toward an effective answer, is most fundamental.

Accompanying this letter is a book by Dr. Fred Schwarz which, I believe, exposes the delusion of Bolshevism and its intrigues in easily read and understandable language. I would like to see literature of this sort abundant in every high school and college in this country.

As you know, an invincible American retalitory force is necessary to prevent our immediate enslavement; however, in ideology and education it is urgent that we must be on the great offensive. In our foreign effort nothing better could be done for the preservation and advancement of freedom than to have this type of literature flowing into foreign university centers in the languages of the countries concerned.

A domestic and foreign education program of this type would have profound and far-reaching affects in advancing the cause of individual worth and sanity in human society.

Thank you for your attention concerning the accompanying book and for the action you take in having such material placed where it will be progressively effective.

Respectfully,

John J. Hartford

John J. Hartford, M.D.

JJH:jc

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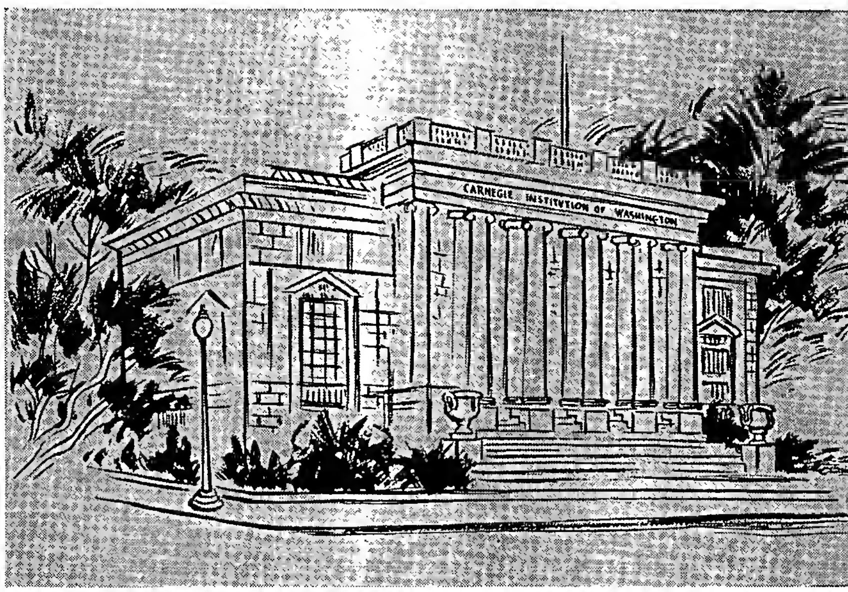
THE *Report* OF THE PRESIDENT OF CARNEGIE INSTITUTION OF WASHINGTON

1959 CIW 1960

THE Report OF THE PRESIDENT



CARNEGIE INSTITUTION

OF WASHINGTON

1959-1960

There have been moments in history when new worlds were discovered. There was such a moment when Columbus discovered America. Creation widened to man's view. There is such a moment now. We are all aware that the immediate future holds within it possibilities different from anything that has been known in the past.

A. N. Whitehead—*Education and Self-Education*

In his youth, the born poet often wavers between science and literature; and his choice is determined by the chance attraction of one or other of the alternative modes of expressing his imaginative joy in nature. It is essential to keep in mind, that science and poetry have the same root in human nature.

A. N. Whitehead—*Science in General Education*

IN A WORLD OF UNPARALLELED ADVANCE IN OUR APPRE-ciation and comprehension of nature, we are privileged to vistas of both insight and wonder inconceivable to our forefathers. Perhaps we are also heir to even keener concerns and more profound problems, rooted at once in the extraordinary command of natural forces that we have achieved and in the unexampled magnitude and complexity of the social questions that beset us. By these very tokens, may not ours be another generation which has the privilege of standing once again at a major crossroad of history, of living in that deep travail which more than once has preceded and ushered in a Golden Age?

What, indeed, is the nature of our own time? Our day is one in which the brilliance and variety of man's concepts, the diversity of his imagination, the extent of his practical power to shape and to use his material environment, perhaps even the penetration of his understanding, have never been remotely rivaled in all of earlier history. It is also an age in which the dangers of man's very existence have never seemed as vivid, as omnipresent, as remote from resolution. For Americans this spirit of the age is twice compounded. For to the problems of living in a world in upheaval, in which it often seems as though vast seismic shifts were taking place before our eyes in the deepest strata of history, is added the insistent feeling that at home too we face new horizons, new opportunities, new hazards, challenges which demand searching reassessments of our strengths and limitations. We are convinced that the values in which our nation and our society are rooted are fundamental to us, yet we are constantly haunted by the feeling—and the evidence—that the means by which we have traditionally implemented and expressed them in the past, if projected into the coming years without innovation and imagination, simply will not be adequate to our future.

All these circumstances lie in the forefront of our individual and our national thinking and feeling. What may be less evident to us is the significance of the very fact of the paradoxes they present, of the very fact of our present

discomfort and dismay. We may forget that the great ages of mankind, the ages of the most radical changes and the longest advances, the ages that later generations of men called great, were not the times of easy optimism when men thought everything discovered, everything architected, everything finished. Greatness and ease, vast innovation and untroubled stability, are no more compatible among nations or in a world community than they are among individuals.

In the heat and burden of the day, the challenges to our democracy which such times present are surely as compelling as those that faced the founders of this nation. Yet current issues differ so greatly from those problems, in range and complexity and subtlety, that we must seek our answers far beyond the eighteenth century. One image which may provide significant resources of inspiration and understanding was little known to the architects of our society—was, indeed, in their day, in a relatively primitive stage of development.

Since the earliest years of American industrialism, an important element of our national character and of our evolution as a society has been molded by our swiftly developing technology and the science which at once led and served it. Today we are predominantly a scientific and technical nation, living in an age itself characterized by the explosive development of science throughout the world. Are there not significant things which the very structure of science as a way of life can say in aid of our understanding of ourselves and of this age and of the task of our nation—this age and this nation so profoundly shaped by science at a secular level, as we all know, and, as we may be less keenly aware in our everyday living, at a deeper and more spiritual level too?

IN THE north and south porches of the famous Gothic cathedral of Chartres, high on its hill overlooking the Eure, stand thirteenth-century carved figures among the most perfectly balanced and most delicate sculptured works of art executed in western Europe since the days of the Greeks. They have long been cited as the very epitome of that new freedom of spirit in the French Gothic which within a hundred years replaced the stylized, often cruel, modes of the Romanesque, with their echoes of Byzantine and Celt. Their naturalism and the fresh imagination that evidently inspired it, well symbolized by the curling leaves just broken from the bud which were a favorite image, ushered in that flowering of the High Gothic of which the cathedrals at Amiens and Rheims are such superb and characteristic examples. These figures of the north and south porches were probably completed between 1205 and 1270. In their lightness and their naturalism and the vivid imagination they convey, they proclaim the attainment at last of a sense of freedom and a vision and a hope wholly foreign to those Romanesque styles which but two hundred years earlier obviously dominated a very different age.

In sharp contrast to these striking sculptures stands another line of figures of a significance more pointed, perhaps, for our own day. These sculptures of the western face are of far different character. They were evidently completed before the great fire of 1194, which largely destroyed the older building, and date, perhaps, from about 1145—a mere century, more or less, before their companions on the northern and the southern walls. The prominent heads and vertical, elongated figures, the rigid stance, and the conventionally stiff lines of the robes, almost Egyptian in suggestion, make each outline more nearly that of a structural column than of a human figure, and mark the work as unmistakably Romanesque in style.

But the faces of these rigid figures are arrestingly different. In striking contrast to the rigid formal bodies, they are of an intense and haunting spirituality, of a loftiness and a deep unease which convey an intense inner disquiet combined with overpowering resolution. They are the spirits that withstood the thousand years of storm and flood, of lightning and of wind-torn darkness that spanned the distance between two great ages—the age of Greece and the age of the High Renaissance. In their faces, and in the curious blend of cultures they represent, are written the intensity of hopes and fears, the clouded but importunate vision that must ever precede a great awakening. These are features created by artists who were clearly the children of an ambivalent society, whose greatest doubts, whose greatest tests of strength, came just before its dawn. When those features are compared with the assurance and command, the far greater art but the lesser inner demand, expressed in the more beautiful and graceful features of the figures of the transept porches, they offer vivid testimony of how indissoluble uncertainty and insecurity and great synthesis and prophecy must be, and on the other hand of how often balance and satisfaction and stability and a conscious sense of achievement among men may be the attributes of mere completion.

Three hundred years later, when Leonardo da Vinci was born in 1452, that particular dawn had become full day. Da Vinci's own incomparable art, and the undying testament of his contemporaries Titian and Michelangelo and Raphael Sanzio, are its permanent proof. But there were other contemporaries too—Columbus and Magellan and John and Sebastian Cabot and Vasco da Gama. Less than thirty years after Leonardo's death in France in 1519 Tycho Brahe was to be born in Denmark, and less than half a century was to pass before the birth of Francis Bacon, and of Leonardo's own immortal countryman Galileo. Casements to new worlds, which would open to undreamed enlargements in man's concepts of the universe and of his more immediate environments, stood just ajar. We have long revered Leonardo as a spirit which crowned the classical Renaissance while offering prophetic testimony to another and a greater age, more popular and more empirical, that was to follow. Our evidence has been the span of his gifts, the incredible breadth of

interest and imagination and energy that has made him, of all the figures of history, most nearly the epitome of the artist and the scientist at one.

But he left another testimony which is more poignant, and more relevant today. It is a testimony of the doubts, the fears, and the sense of disaster that must beset the most sensitive and prophetic of those who walk the corridors of change. Among the later drawings that survive from this artist who by the contemporary accounts showed to the world a nature predominantly of kindliness, of optimism, of radiant magnetism, there is a group of miniature sketches portraying scenes of massive and catastrophic human suffering and of calamitous human disaster. In them, helpless crowds of men and women are overwhelmed by flood or tornado or consumed by fiery holocausts whose curving whorls of smoke and flame are set out with a careful and a devastating accuracy against the human agony. Nothing could so contrast with the serene beauty of Leonardo's faces to which we are more accustomed—to the spirit of a Mona Lisa—than these creations, with their overtones of violence and disaster and despair, and their curious mixture of art and of coldly analytical descriptive science.

At Chartres, and again three hundred years later in Italy, the story is dramatically repeated. A brilliant and a predominantly classical age is jostled by a new, with its secularization, its promise of a broadening of horizons beyond men's wildest dreams, its widely shared revolution of attitudes to the world which no man can predict in detail but which a few men can dimly sense. Eagerness and undefinable excitement, instability and danger, an intoxicating and a suddenly expanding delight in the new ideas and in their communication compete for men's minds and their emotions. And for those who have pioneered the older age or have brought it to maturity and fruition, for those who stand on the threshold and sense its portent without, often enough, being able to see the form, there is suffering and despondency and even transient despair. In the faces of the west porch of Chartres and in the fantasies of disaster of Leonardo are the marks of the somber but deeply characteristic elements of two of the great passages of history—elements which, in moments of doubt or of discouragement, we shall do well to bear in mind today.

Through the centuries that followed, the changing panorama of our civilization has evidenced and re-evidenced that truth. We are vividly aware, today, of the developments that followed da Vinci's doubts and questions and troubled anticipation—the waves of exploration of the physical world beyond men's most vivid imagination, the discovery and exploitation of huge and unsuspected natural resources, the new audacity and confidence that they brought, the giant strides of commerce and communication and widened social participation that followed. We know the advent of a new way of looking at the world which Leonardo foreshadowed, the mode of modern science, emerging from its long, slow preparation in the trusteeship of the Greeks and

Moslems. We have vivid experience of how much part and parcel of all men's evolving worlds this new realm of science was to become, how sensitively responsive to their moods and needs, and, at a level both subtle and intricate, how accurately it was to portray each new age which nourished it.

It is no accident that the mathematics of insurance and the computation of rates of interest underwent a great development in the years of the later Renaissance, when commerce was expanding so explosively. It is no accident that the years when the primitive arts of navigation served a primary frontier of man's advance were also the years when the first telescopes were designed, and when the scientific study of optics and hydraulics and the building of clocks and with them deductions from their mechanism to the processes of life preempted men's enthusiasms and preoccupied their minds. These, and a hundred others, were the currents of desire and need and sensed opportunity that ultimately produced a Newton and a gravitational theory and gave to modern science a characteristic, enduring stamp. When trade and commerce and invention replaced navigational exploration as a primary lifeline of nations, it was such men as James Watt and Edmund Cartwright and Eli Whitney, and, at another level of understanding, Michael Faraday and Joseph Henry, who became the architects of a new and different scientific age. And now when man looked in upon himself or considered other living organisms as physical phenomena once again he saw them and himself as mechanisms of the kinds he knew—more complex now: as elaborate and subtle machines operated by strings and pulleys, or hydrodynamics, or electric currents, as instruments for the conversion of power, animated by some distinctive *primum mobile.* Now when man examined the nonliving world, he strove to reach the heights of objectivity of a Newton. Right down to the beginning of our century, indeed, he strove to separate, as rigorously as possible, the observer and the thing he observed, resistant almost until our day to entering doubt that they might in truth comprise one system, interlocked and inextricably joined. In our own time, it is no accident that communication and game and information theory preoccupy us, that considerations of prediction and of contingent probability strongly color our thought about life processes, that the molecular structure of the chromosome and the information-coding aspects of its mode of action are frontiers in our thinking about heredity.

So it is with the whole history of the growth of modern science. Everywhere it took its character from the conspicuous needs and opportunities of the time, developing greatness in those areas where it was most needed—where the age demanded, detected, and rewarded greatness. And everywhere its spirit was in turn reflected in the society that it served. Surely it is not accidental that the centuries of the flowering of modern science have also been the centuries of the rise of the Western concept of the dignity, the uniqueness, and the essential worth of the individual. Perhaps it was not accidental, too,

that these were also the centuries of the genesis and ascendancy of the modern nation-state as we, its latter-day contemporaries, understand that term.

In all this tremendous evolution of science there recurred from time to time, just as in the larger evolution of cultures, periods of a settled and rationalized optimism in which men took brief and too smug satisfaction, little enclaves in the march when, it was said, everything was perfected, everything finished. Such, for instance, in formal Western science, was much of the eighteenth century, when the Royal Society of London turned back upon its brilliant promise in the days of Newton's presidency and sank to the level of a club for polite dilettantes. And there was that later day of May 24, 1859, when Thomas Bell, the president of the British Linnean Society, in reviewing papers that had been read before the Society in the preceding session, expressed his regrets that the session had passed with no evidence of "any of those striking discoveries which at once revolutionize, so to speak, the departments of science on which they bear" or "produce a marked and permanent impress on the character of any branch of knowledge." In fact, it was during that term, on July 1, 1858, that Charles Darwin and Alfred Russel Wallace had read before the Society their joint contribution *On the Tendency of Species to Form Varieties*—the first formal statement of the theory of evolution. And we forget, nowadays, that several Fellows withdrew from the Linnean Society in protest that Darwin was not expelled from membership for the publication of the *Origin of Species.*

Less than a half century later, at the beginning of our own century, there came another, similar period, this time for physics, when everything seemed to be completed and known—the era which once again, by the same seemingly typical just irony of fate, immediately preceded the revolutionary discoveries of the structure of the atomic nucleus which have so shaped our own time.

But the main trends in science, as in the rest of our recent civilization, have been far different. Their stamp has been instability, vast shifts in man's concept of his universe and his place in it and of his own very constitution and nature, delight in ideas, or sheer fascination with them because of their compelling sweep and force, and an overwhelming urge to communicate them broadly and to share widely in them. The ages that have witnessed these trends have been characterized, too, by the attainment of new levels in the physical well-being and the moral and spiritual horizons and opportunities of the individual. Together with all these developments, and both as cause and as consequence of them, new and widely voiced demands have typically appeared—demands for innovation in the structure of society, reflected in social and political insecurity, in rapidly shifting patterns of political and social organization.

THE MORE one contemplates our own time, the more it seems to resemble those earlier dynamic and critical eras of Western history so typically characterized by a keen sense of change and exploration, and also by an atmosphere of personal and political and social insecurity. No one observing the eagerness with which developments in the exploration of space, for example, are currently watched and commented upon and interpreted by all the peoples of the globe can forget the world of Leonardo, into which Columbus and Magellan and Vasco da Gama were born. Our time is marked by the same sense of new physical frontiers close at hand, the same ferment of new ideas, the same vast and rending shifts in the individual's notion of the universe and his place in it, and, most poignantly, of his very nature. There are the same new and violent and still little-understood demands of political and social organization, in a world whose huge and shifting tides bring new and untried peoples to the political level of the nation-state just when the nation-state in its primitive form is elsewhere passing from the world. And there is the same intense need for vigorous and imaginative leadership in every field.

In all these aspects, our own age may indeed be quite typical of the most significant eras of change in the fifteen hundred years since the fall of Rome, differing primarily in the greater intensity and scope of an enormously more complex world. Yet some of the changes with which we are concerned so vastly exceed those that occupied other ages as almost to differ in kind. The sources of physical power which have been uncovered and brought to use in our era are evidently of a different order of magnitude and of variety from any that man has known before. Concomitantly, the burden which we place on our natural resources is greater by orders of magnitude than we have experienced before, and is quite clearly still near the beginning of its expansion curve. The world communication of ideas, always a feature of the great ages, now so far exceeds in volume, range, and speed what we have ever known as to bring social and intellectual implications of a wholly new character. The capacity for essentially instantaneous communication, indeed, as has recently been pertinently noted in connection with the observance of the three hundredth anniversary of the Royal Society, has been a primary gift of engineering to the second half of the twentieth century. Power is carried in seconds from waterfalls to cities. Messages are transmitted in moments from one continent to another. Computers are able to perform in microseconds calculations that would require days or years for the human mind—if, indeed, it were capable of encompassing them at all. It has taken a major human adjustment for the West to accustom itself to this range and speed of communication, deeply affecting all its affairs and driving society at a new pace. And now, in our immediate future, new nations must make this same great orientation, in a world which allows but little time for major readjustments of international affairs.

Our age brings difficult paradoxes and radical shifts of concept at a more subtle level which must challenge us with more imminent and even more telling blows to our sense of competence and security. In an era which offers unrivaled opportunities for individual development the very pressure of population and the intricacy of modern life demand new levels of human integration. It is a demand that will tax our ingenuity to the utmost if we are to live successfully in a world where complex and powerful organization is an overriding factor without at the same time suffering an intolerable shrinking of the sphere of the individual. Again, in an age that has succeeded in unlocking the sources of physical power to a degree unimaginable to earlier times, the control and modulation and organization of this power now must claim our particular attention. That is a claim that can bring as profound changes in our concepts of the universe and of ourselves as ever were wrought by the physical exploration of a new continent. At the very time when we have achieved almost the instantaneous transmission of messages, the mode of generation of the message and the assessment of its content of information become primary targets of inquiry and research. And with these developments are coming once again vast upheavals in the individual's vision of his own nature and his relationship to his world wrought by the profound developments in science and philosophy since the advent of quantum and of relativity theory. What wonder that an age so challenging, so richly rewarding but with such high and irrevocable penalties for failure, should engender the dread that we so often see, the "turning away" that factors of such poignance must bring when they press in inhuman measure? Such times call for an order of leadership and an order of excellence in every sphere greater than we have ever known: a leadership of greater force, greater knowledge, greater understanding—and a leadership yet more widely dispersed in every level of our society.

Once again in our time, as in the times of Newton or of Faraday, science serves as a mirror of the wants, the hopes, the fears, and the visions of the societies that nourish it. Although science is but one among many modes that affect the course of a society or reflect the nature of its concerns, it is a peculiarly sensitive and prophetic one. For science by its very nature, in the modern day, is a provider of both sinews and ideas to the societies that it nourishes—it is at once a spiritual and an intellectual way of life and a very practical and powerful way of getting things done. This is especially true of our own time and our own nation, in an age where scientific matters form so considerable a component of the fabric and the concern of our society. So it is especially interesting to think of science within the framework of the character, the aspirations, and the contemporary needs of our own nation.

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We have always been a pioneering, an experimenting, and a deeply purposeful people. These attitudes, with their pre-eminent concern for the future, their fundamental tenet that nothing is—or should be—finished, that the past is but a foretaste of what is to come in different and better measure, constitute our basic inheritance from a wilderness land where the challenges, though severe and taxing, were not insurmountable. Those tenets have formed a core of our being, a foundation of our greatness. They have not changed essentially in the two centuries of our nationhood. They represent our most fundamental ethic, the most priceless heritage that we have to conserve.

From that heritage follow beliefs of equal import. The reverence for the individual and his rights, the belief that most creation is, at base, individual, spring from the foundations of our original national ethic, itself a Renaissance inheritance. They have been constantly reinforced by the continuing evidence that in a pioneering culture, where innovation is all-important, the individual in a practical as well as an ethical and a spiritual sense is indeed the vital fount of a society. We have felt profoundly that individual excellence is our most exalted goal. And with this conviction has always gone, as de Tocqueville long ago observed, a deeply religious ethic, which in fact gave birth to large sectors of our society and still shapes our attitudes and motivations. We still know that the essential worth of life for the individual lies in a dedication larger than himself. We are learning, now, that the wisdom of total dedication spans the workaday world no less than the religious realm.

We have always been a nation of buoyant optimists, convinced that nothing is inherently impossible, that, at most, it may take a generation or two to modify the course of events to suit our needs, just as it took a generation or two to accomplish the winning of the west. And, finally, we have a keen appetite and a native relish for situations in which the means are relatively well known but the ends are large and uncertain. It is very important for us that our goals shall in the main be unknown until we have achieved them; that they shall be larger than our means, and perhaps larger than our dreams; and, above all, that when they are finally within our grasp, we have the opportunity to pass on to the pursuit of other and more distant goals, still all but hidden over the horizon, still the foundation of dreams as well as of fulfillment.

In America the technology at which we were traditionally so apt and the science which was its later consequence and leader burst upon a society which had not yet crystallized its patterns. Their revolutionary influence brought material prosperity as well as intellectual satisfaction, and they soon assumed so dominant a role in the infant society that its principal modes formed easily

around them. Thus it was, perhaps, that the curious dichotomy between an essentially conservative social structure and a radical technological and scientific one, by which we live, came into being and persisted and grew through the years. Thus it was, perhaps, that some of the most socially conservative of our highly gifted citizens, some of the early great industrialists, became the most radical social innovators of their age. Even more important, this curious and apparently almost fortuitous circumstance of timing may have had a major contributing influence on the extent to which the very structure of science and technology, in our day, has come to mirror and epitomize, sometimes with extraordinary emphasis and accuracy, the essence of the democratic way as we conceive it.

Science is today, as it has always been, in essence a society—a society made up of individuals committed to the pursuit of truth wherever it may lie, a society with extremely high standards of conduct. They are standards, moreover, which must be maintained not only out of strong inner belief in them, but as well for the less lofty but pragmatically compelling reason that, unless they are so maintained, science simply cannot function. The rules of science are flexible in content but uncompromising in principle: dedication to the search for truth, dedication to unconformity, dedication to rigid discipline and economy and parsimony of thought, to communication among its members, to the continuous checking and cross checking and agreement and disagreement which not only can alone ensure the elimination of error and misconception, but which, at a deeper level, almost certainly ***constitute*** the truth in our modern definition of it.

It follows that in science, as in our larger democratic society, the individual is still a supremely important factor. In a related sense, science, like democracy, must enthrone the values of private concern, embodying and sternly defending those sectors of individual effort for which no collective element may substitute. Again science, like a democracy, has made an institution of the process of continuous reorientation, in a sense, of continuous reform. A science that is faithful to its trust, like a democracy that is true to its being, will refuse to claim that its work is ever done. Neither the success of science nor the success of a democracy can ever be taken for granted. It is quite possible that science may be able to supply, may indeed be supplying to a significant degree, one of the greatest needs of our larger society today—the continuing demonstration of human perfectibility, the constant stimulation, and recognition, of individual excellence, albeit in one particular sector of living. In so doing, it may well be providing one of the important incentives for individual achievement. Like our greater society, the society of science at its best is deeply motivated by an ethic at once basically religious in character and dedicated not only to the supremacy of the individual but to that spirit of

frontier unconformism which is such a pronounced and precious element in our own tradition.

As Walter Lippmann has aptly observed, Americans stand today in need of fresh road maps, and, once again in our history as so often before, of great innovational leadership. As an internal problem, we have now to live successfully with and successfully dispose the large resources, personal and national, that our genius and hard work and incomparable good fortune have brought to us. We have the problem of redefining our unknown ends, now that we seem to have attained many of the old ones. Perhaps most important of all, we have the tremendous problem of maintaining our old aptitude and appetite for excellence—not only because they provide us with the one goal which is immortal and is of all most deeply satisfying, and which of all our ends most clearly epitomizes our dedication to the worth of the individual, but for the further very practical reason that in a perilous, highly competitive world our survival as a free people requires nothing less.

The coming years, moreover, will bring a new and most important kind of challenge to our verve, which will demand all our reserves of understanding to meet and to surmount. That ingrained optimism, that belief that the future is on our side which is one of our most precious assets as a people, is evidently rooted in part in our domestic environment and in our proven past successes. But it is a product too of other very special aspects of our history, as Robert L. Heilbroner has pointed out. We began our nation with the protection of two oceans, with weak competitors at home and divided enemies abroad. At our door were reserves of wealth probably unsurpassed in the experience of pioneers, wealth which required ingenuity and application, skill and toil, to exploit, but the realization of which was never beyond the power of able men. We inherited a land free from social constraint, or indeed from social patterns of any kind that were relevant to us. We were blessedly free, and knew that we were free, of an oppressive and abiding past. We did indeed inherit the priceless asset of the *tabula rasa,* so far as our new environment was concerned.

These circumstances have left us with the firmly rooted conviction that, if we but strive sufficiently, history and the future must do our bidding. It would be extraordinary—and profoundly tragic—if we were really to doubt, today, that we can remake any situation to our liking and our need. But there is an obverse to this coin. As a mature nation, now, maintaining ourselves in a world of unmatched danger, faced with challenges more severe than man has ever known, no longer protected by our oceans and quite as vulnerable as any other people, our old concepts about the future must be critically sharpened if we are not to be needlessly and damagingly disillusioned

in ways that could seriously affect our verve and our philosophy. For it is inevitable, now, that we shall encounter large factors in our future which we cannot immediately manage to our satisfaction, no matter how hard we try. Inevitably we shall sometimes find ourselves in situations where our power of will in the short run, try as hard as we may, will not suffice. These will be tests of a new order of severity. We shall be tempted to accuse ourselves, and especially representative individuals among us, of incompetence, or mismanagement, or wrong action, or insufficient action. We must continually remind ourselves, in these circumstances, that the forces of history are titanic when we are fully exposed to them, and more than ever so in our own day. We must remember that a keen sense of what to expect and a keen general instinct of how to react may be as important as an immediate design of action. Above all we must learn to live steadfastly with such situations over an indefinite future, knowing and firmly resisting the temptations, which will unfailingly come to us, to abandon even for a moment the fortresses of our being—our verve, our optimism, our humanity. Above all else our actions must continually reaffirm our faith in our deepest ethic—our loyalty to one another, our refusal to refer the shortcomings of all of us and of our situation to the easy scapegoats of particular men in particular situations, and most of all, our continued reverence of the individual. Here science may be particularly helpful, for in its multifarious encounters with a difficult and unknown and frequently intractable world it long ago developed special skills, based upon these truths, for meeting such situations.

It is clear that science is one of the most precious spiritual and moral, as well as material, values in our society, and that it serves us today in a particularly critical time—and nowhere more so than in its emphasis upon the individual. Movements of history have typically been initiated by individual, unconforming men. Originality and independence, individual dissent, properly protected, are the very essence of our civilization. Calvin and Spinoza, dissenting Puritans and Yankee husbandmen, a John Knox and a Washington and a Roosevelt and thousands more bear testimony to the power of the individual. And in science, whose basic task is innovation and whose greatest weapon is originality, this truth is epitomized: Newton and Einstein, J. J. Thomson, Rutherford, Darwin, and Pasteur, and hosts whose contributions are publicly less known, all furnish the immortal demonstration of it. For science in its public function, now become one of its greatest, the protection of the individual and his independence, the honor of free thought and free expression, the public welcome of dissent, all are utterly vital. The enemies of these in our time are particularly dangerous because they are not tangible and dramatic, but amorphous and difficult to see. They are not formal

oppression or suppression, or even organized intolerance. They do not take the shape of the great and striking social injustices which we have known and fought before and so can recognize and be on guard against. They are more subtle, more insidious factors—inattention, lassitude, hostility to innovation arising from failure to recognize that innovation must, of its very nature, be antithetic to established order, and that we must embrace that antithesis for the life blood that it brings. Perhaps most important among these subtle dangers for the scientific way is the threat of simple, widespread, massive misunderstanding of its nature, its purpose, its indispensable place and part, not only in our practical world, but as a vital part of our deepest philosophy and belief.

It is disturbing, therefore, to note a gulf, in feeling and sympathy, which frequently exists between those who practice the scientific way and those whose commitment lies with the nonscientific sector of our cultural heritage—the dichotomy of "the two cultures." This is a conflict rooted far in the past. But it has become greatly intensified in our time, to the disadvantage of both humanistic and scientific disciplines. In our own day we can ill afford the misapprehensions that it entails. There is much, in fact, to suggest that the apparent dichotomy may be basically unreal, and it is worth careful analysis.

The common factors that unite all the creative disciplines, be they artistic or humanistic, philosophical or scientific, are far deeper and more fundamental than the more obvious differences that distinguish them. We are apt to neglect the fact that, with the possible exception of authentic genius and some very specialized kinds of talent, good minds in the one culture tend also to be good minds in the other, and to forget how frequently in the earlier days of scientific effort, before the sheer weight of learning and of evidence forced our modern specialization, many great figures united the two fields. We forget, too, that historically the older periods of cultural burgeoning in the world have also been the periods of the burgeoning of early science. Shall we classify da Vinci, at last, as scientist or humanist—or Socrates, or Plato? What shall we say of Copernicus, whose education was in the classics, and law and medicine? Shall we forget that Omar Khayyam was a Persian astronomer, or that the motto of the Royal Society of London was given it by John Evelyn the diarist, that Samuel Pepys and the poets John Denham and John Dryden were among its first Fellows, and that the opening lecture of the Society—on astronomy—was given by the architect Christopher Wren?

Furthermore, as H. M. Dowling has keenly perceived, in our own time good minds introduced to the sciences and the humanities early enough and as coherent structures rather than as collections of isolated and apparently unrelated ideas, will characteristically retain a lifelong sympathy with and gen-

eral understanding of the objectives of both. Moreover, the mind that has once been opened to a real appreciation of the one field must perforce acquire a much better understanding of its own domain, however distant it may superficially appear to be. Conversely, men who misunderstand the deeper currents and purposes of their own work can never properly appreciate the work of others.

At their most general level, the characteristics and the objectives of the arts and of the sciences are of course essentially identical. Both are primarily concerned with the process of discovery itself, and with discovery of the beauties of nature. Both professionally excel in innovation, and take delight in the shapes of things, their patterns, lights, and shades, and in the uncovering of hitherto unperceived relationships. Both strive to cast their descriptions and discoveries in evocative and universal forms. The successful evocation, the stimulating or inspiring chain of thought or feeling links the worker with his audience—the critic and the witness and the final judge. At a very profound level of understanding, both take *communicability* and *coherence,* within the subject itself and with the audience, as the ultimate criterion of conceptual or of demonstrated truth.

Both take their very living being and draw their vitality from the joy of discovery, from the attaining of ends unknown when the work was begun, through means which are indeed partly or wholly known, but are usually of technical difficulty. Both are deeply concerned with the underlying likenesses between superficially unlike things; with the equating of different aspects of the same phenomena; with uniting such apparently disparate aspects in common matrices; with the generalizations which follow the painstakingly minute analyses; with analogies and their testing. In this, of course, they are not only typical of all the most creative and imaginative pursuits of man. They are typical of the ways in which, today, we are suspecting that our very minds operate. They are typical, indeed, of the life processes themselves, vitally concerned as these must be with synthesis as well as with analysis, with generalization as the final adaptive crowning of the stages of analysis that are first steps in life's survival. Finally, the arts and the humanities, quite as much as the natural sciences, must be truly consonant with our contemporary history. All of them sensitively express the spirit of their age and their civilization at its highest. As faithfully as they reflect their period, so they are reinforced by the societies that nourish them. It is a great responsibility that they bear.

But of course the deep-lying similarities between the disciplines of the arts and the humanities and those of the natural sciences cannot obscure differences that do indeed exist at another level. They are important, and they must be fully recognized and thoroughly understood. Perhaps they may best be

summed in the antitheses we have long recognized, if more intuitively and generally than analytically and in particular, between what we have often somewhat vaguely characterized as the *additive,* versus the *nonadditive,* branches of learning.

In the arts and in the natural sciences, alike, it is indeed true that communicability and coherence, as Martin Johnson long ago pointed out, are the essence of truth, and the discovery of truth is the objective of both. But it is worth noting that in art such coherence must be primarily *internal,* uniting the parts of one creation. In the natural sciences, however, it must be in a sense *external,* at its best uniting in one theoretically coherent frame the fruits of many thinkers, whose work is often extremely disparate in character.

Communication and communicability in art must extend primarily between the creator of the work and his audience, at once his witness and his critic. Such communication comes primarily after the work itself is finished. In science, on the other hand, this communication occurs at least as actively during the actual progress and structuring of the work as after its completion.

Science, therefore, in a very deep sense is basically a communal activity. Though the great steps of innovation lie most often with the individual, "truth" for science cannot rest with him, however comprehensive or penetrating his genius. In our day more than ever before it must perforce inhere in a whole composite fabric of evidence and interpretation, derived from a great body of communicating investigators examining nature from a multitude of viewpoints. Truth in our day, indeed, must be a *property* of this common fabric of accepted knowledge shared among all the working scientists in a given field—and, indeed, in a wider sense, shared in comprehension by a multitude of interested though nonparticipating observers. Of all the newer extensions of concept in the philosophy of science, this, a product of the more recent years of our experience, is perhaps the most profound. It is for this reason that the scientific community in its essence is basically a world community, surpassing the boundaries of nations. As Pasteur said so penetratingly, "Science has no homeland"; presciently he added "but a scholar has one." There is an inherent paradox in the circumstance that the second aspect of science, as a fabricator of practical power, makes of it a peculiarly national community as well. This particular aspect of the scientific effort probably does not find a close counterpart within the arts.

In the arts, imagination alone may fix the final limits of experience which can be shared. In the sciences, on the other hand, however indispensable imagination may—and indeed must—be in discerning those limits and in reaching the goals that they define, the limits themselves are fixed and determined, in the last experimental analysis, by the concrete evidences of verification and therefore, ultimately, of the human senses.

There is an important inherent qualification in this inescapable position of the natural sciences. Since the final criterion of communicable truth is here the *observation,* repeated in many times and places, by many workers and under many conditions, and since, as we know today, all observations of the world are of their nature relative, we have to recognize that this "ultimate" criterion must be relative itself, joining the observer and his environment in a system from which he can never be isolated.

From this communal characteristic of science there follow many striking contrasts between its operating modes and those of the arts. The arts must always make place of honor within their ranks for the lonely, creative Titan. The sciences, too, ultimately look to such giants for their great advances; but these men in turn are immensely dependent upon all their fellows, including among them a wide range of more particular talents—the minute observers, the keen analysts, the able accomplishers of specialized technical work. So these men, too, become integral and indispensable elements in the operating structure of the sciences to a degree that is difficult to conceive within the arts.

From this basic quality, of course, follows the strong tendency to specialization so characteristic of the natural sciences at the present day. The fact of specialization in science is strikingly two-edged in its implications and consequences. Specialization in science is fundamentally essential to scientific progress. For progress in science, in its most general sense, must ultimately come from that penetration whose indispensable tools are minutely particular knowledge and expertly sharpened intuition. The classic observation of Pasteur that science favors the prepared mind is more than ever true in our day. Yet specialization also erects barriers that are basically inimical to that communication within the whole body of science upon which truth alone must finally rest. This barrier to communication is not one of language only, as is too often imagined. We are prone to forget that in all our affairs words and the concepts for which they stand are intimately and subtly interlocked. So the barrier is more than one of words—it is frequently a barrier of comprehension or even awareness of the underlying concepts that the words must try to convey. Yet at the same time this fragmenting of science in the course of its development has historically offered rich opportunities for pioneering along boundaries by men who have been willing to acquire competence in two or more apparently disparate disciplines which yet are significantly related. Physical chemistry and chemical physics and geochemistry and geophysics have testified how rich and illuminating such borderlands can be; the sciences of biochemistry and biophysics and borderlines between neurophysiology and studies of behavior, to name but three, offer contemporary testimony that is equally compelling.

There are important differences between the sciences and the humanistic disciplines in yet another dimension. The primary task of both the humanities

and natural sciences in a peculiarly subtle sense is to illumine the future as well as the past. The primary business of the arts and the humanities, quite clearly, is to create and to communicate that creation. But to this responsibility the natural sciences add another—in a very special sense, that of building a fabric of prediction. The idea that the final task of science is the tracing of relationships of cause and effect has only an ill-defined meaning, in the light of our present concepts of the universe. But however meaningful such a view might be, this task in any case would not be the overriding challenge. That primary challenge, for science, is conditioned instead by its delight in the search for grand recurrences in nature. Such a search for regularities must ever, in the final analysis, resolve to the process of prediction. Science professionally predicts, and in this it may actually be closer to the essence of living things than the arts. For the basic processes of life itself are those of prediction. What else, indeed, is the phenomenon of instinct at its functional level than the process of correct prediction, requiring little immediate information for its successful execution but relying heavily on regularities in the environment, which for its success must be quite faithfully maintained? And what is that property which we call plastic intellect, or even genius, but the ability to predict successfully, relying heavily now on current information and less dependent on invariant features in its world—though in the end dependent, as all men, and indeed all life, must be, on some degree of repetition in the universe?

Finally, the natural sciences differ from the arts and the humanities in a pragmatic way. In its second genre, as a means of getting things done, science has obviously become the architect of great material power, and what it has accomplished in this field in the past is likely to pale before what the future holds.

SO IT WILL NOT be easy to heal the rifts that have grown between the kingdoms of the humanities and the natural sciences, between the bodies of thought that they comprehend and the men who are their practitioners. It will not be easy to bridge the gaps of understanding and of sympathy that ideally should not exist between them, or to undo the damage that these rifts have certainly brought, or to eliminate the dangers that they pose for the future. And yet the fundamental similarities, the bonds of common purpose and of common taste which unite them more strongly and more deeply than the differences can divide, are plain for all to see. They are the foundations on which to build.

In times of unexampled excitement and opportunity and of great peril, times when uncertainty is coupled with new heights of concept and of execution, a

philosophy rooted in the currents of our time at their deepest level is vital to our future. Perhaps the understanding demanded by that challenge can find a significant dimension in the image of the scientific way as it exists in our society—not so much in its secular aspects, important as these are practically, as in its deeper philosophy and spirit.

For this reason, a reason quite apart from any inspired by practical considerations and in the end, perhaps, far greater, it is imperative that we understand the nature and the needs of the scientific way and comprehend the dangers that may menace it. Such an understanding of the society of science can provide penetrating insights to the nature and the needs of our larger society. It may help to light the vision that alone can inspire leadership in a critical period of history whose challenge for the future may well be without parallel in all of human experience.

The Year in Review

It is my privilege to report once again upon the progress made by the Departments of the Institution in their dynamic research programs. In a year when the activities of scientists have been almost daily news to the public, the achievements of the staff of the Institution have been most reassuring. Only a few, to be sure, have been of the substance that leads to headlines. But very many have been exciting and highly significant to the scientists who participated in them, and exciting and illuminating to those privileged to watch their progress. As in previous years, the range of interest and attention has been enormous, extending from the tiniest particles of life on this planet to the outermost galaxies detectable in space. The staff of the Institution operates not only in a dynamic professional world of increasing massiveness, complexity, and versatility, but also in a physical world limited only by the sensitivity and power of resolution of mind and instrument.

In mere numbers the total professional staff of the Institution is but a very modest part of the now huge scientific establishment active in the United States. The rapid growth of American scientific effort, particularly under the stimulus of federal grants and federal agency employment, is one of the striking features of our present-day culture. Because the effort is vastly different from that prevailing during much of the Institution's history, it makes a most interesting background for viewing our current work.

The scientific effort of the country, both privately and publicly supported, reflects several trends that abet the greatness of the nation. The value of uncommitted research is recognized now more generously and appreciatively than ever before in our history. No longer are we viewed in Europe as the culture which only takes fundamental discoveries from other lands and applies them to practical ends. Instead, Americans are regarded as indispensable fellow contributors on the common frontiers of fundamental research. The precision of American scientific equipment and methods is now known wherever advanced research is undertaken. The range of subjects explored with their aid is ever widening.

Hand in hand with these strides, an increasing sensitivity to and aptitude for discovering and pushing forward "growing points" is appearing in the vital disciplines. Often such points are at the line of contact between disciplines. Often they are heavily dependent on theoretical studies for guidance. Increasingly, the effort of our science mingles the interests of the past disciplines. A reflection of this is the growing rapport between basic and applied science—indeed, they really form a continuum. The research scene may currently be viewed as one not of "pure" and "applied" science but as one of "science" and of "science applied." Finally, it should be a source of great satisfaction to us that widely within the United States institutions are actively seeking out opportunities for advancing science throughout the Western world, and are deepening the ties of Western nations by building or strengthening science research within many of them.

Several of these trends illustrate values to which this Institution has been deeply committed for many years. Nowhere, indeed, has the spirit underlying the work of the Institution been given better expression than in this year's report of the Director of the Department of Terrestrial Magnetism. "Basic research . . . has the goal . . . of increasing and sharpening man's awareness of the beautifully intricate and orderly world in which he finds himself." The meaning of these words is superbly illustrated by the year's work in each of the departments.

Among the general fields of basic science in which "growing points" have been particularly visible in the nation during the year are geophysics, the observation of outer space and of the stellar universe, and the study of the cellular structure of life and of its nature at the molecular level. One need only mention the current additions to our knowledge of the earth's outer atmosphere and the electromagnetic fields surrounding it, the suggestive evidence obtained of the possible existence of life on Mars, and the artificial chemical synthesis of chlorophyll. In all the fields of geophysics, astronomy, and the life sciences research workers of the Institution have actively contributed during the year toward an understanding of our "beautifully intricate and orderly world."

By its very nature, any important discovery in astronomy is always exciting to the imagination. The Mount Wilson and Palomar Observatories report once again a spectacular new view of the "edge" of our known universe. During the year Dr. Rudolph Minkowski photographed through the 200-inch Hale telescope the most distant astronomical object thus far discovered. It is a cluster of galaxies apparently receding from the earth at the rate of 138,000 kilometers per second, almost half the speed of light. This discovery is an interesting example of the pioneering that can follow on close interdisciplinary cooperation. The cluster was first located accurately by radio astronomers at the Cavendish Laboratory in Cambridge, England, and at the California Insti-

tute of Technology's new Owens Valley radio observatory. The cluster proved to be a strong source of radiation in the radio range, particularly at the longer wavelengths. This suggested that galaxies within the cluster are in collision, as has been classically illustrated by the much nearer source of radiation in Cygnus A. Accurate location by radio receivers, the resolving power of which has been greatly improved in recent years, made possible the remarkable spectral photographs obtained by Minkowski.

On the basis of the redshift relations found (the displacement of characteristic spectral lines to the red), it is estimated that the newly discovered cluster is eight times as distant as the colliding galaxies in Cygnus A. Although the distance of these new galaxies from the earth cannot be precisely determined yet because of uncertainties about the redshift/distance relation, it is certainly of the order of several billion light years. Spectra obtained by Minkowski identified one of the brightest galaxies within the cluster as the radio source because it contained the $\lambda 3727$ emission line characteristic of such a source. Multicolor photoelectric measurements of two fainter galaxies in the same cluster by Baum confirmed Minkowski's identification. Baum's measurements also gave precise values for the magnitudes of the galaxies in the cluster.

The year at Mount Wilson was also marked by a striking stellar age determination. Sandage, in a photometric color magnitude study of NGC 188, produced evidence that this galactic cluster may have an age of 25 billion years, the oldest thus far found for any group of stars.

A third discovery of great astronomical interest during the year was that of the strongest magnetic field so far found in nature. H. W. Babcock determined that the star HD 215441 showed at one stage in its fluctuation a general magnetic field of 34,400 gauss. For comparison, large sunspots have been determined to have magnetic fields of about 4000 gauss.

Several other discoveries likewise of much significance were made at the Mount Wilson and Palomar Observatories. The group working with Greenstein on the chemical composition of stellar atmospheres continued to find stars showing large deviations from the composition normally observed in the sun and other stars in its neighborhood. Several stars or star clusters were found to have deficiencies in the abundance of metals by a factor of a hundred or more. Among a number of the stars investigated the two light elements lithium and beryllium showed especially large fluctuations, although other elements also varied markedly. One star (3 Centauri A) was found to have a hundredfold greater content of phosphorus than the sun.

Discoveries of such extreme situations are of interest not only as sheer curiosities or aberrations but more pointedly because they often have great indirect significance to the observing science. Such extreme situations, for example, may provide crucial tests for important theories and furnish vital data for

testing the validity of contradictory models attempting to represent reality. Astronomers have to deal with some of the most fascinating and difficult problems in all of science in constructing cosmological models and evolving theories about the origin and age of the universe. The discoveries outlined briefly above are illustrative. For example, the relation between redshift and distance yields a significant set of clues for discriminating among several models of the universe. The velocity and magnitudes of the very distant galactic cluster so accurately determined by Minkowski and Baum will be of great importance in future studies of this relation. Similarly, Sandage's color-magnitude measurements of NGC 188 must cause us to re-examine carefully current theories of the age of the universe. If Hazelgrove's and Hoyle's models of stellar evolution are correct, the age of stars in NGC 188, using Sandage's measurements, is about 25 billion years. On the other hand, if the best current value of the Hubble redshift constant is used in an exploding cosmological model, the age of the universe is only about 7.4 billion years. Thus either the traditional exploding cosmological models are incorrect, the value of the Hubble parameter is incorrect, or the ages from the more recent stellar models like Hoyle's are incorrect.

The unusually strong stellar magnetic field is of particular interest because consideration of the influence of magnetic fields has not played a prominent role in current theories of stellar structure. The anomaly presented by the field of HD 215441 suggests that the subject is well deserving of further study.

Finally, the deviations in chemical composition that have been observed in stellar atmospheres also raise questions basic to the structure and dynamics of the universe. A constant comparability of luminosity and period among the cepheid variables has been an important presumption in their use as distance indicators. What effects may these recently observed chemical variations have on their luminosities and periods? Furthermore, how do thermonuclear processes produce the anomalies that have been observed? With such major questions before it astronomy continues to be a frontier science in every sense.

Nowhere are the vigor and penetration of current methods and the power of new tools better illustrated than in the wide domain of geophysics. The striking recent accretions to our knowledge of the atmospheric envelope surrounding the earth and the earth's electromagnetic field give us a new view of our immediate planetary surroundings. Because many of these discoveries have been associated with missile probes or orbiting satellites, their existence is commonly known. Not so well known is the less publicized, but equally penetrating and equally important, application of geophysics to the study of the earth's crust. This field has been the focus of attention of another extraordinarily interesting and productive Institution program.

No section of the great field before science more aptly deserves the description "beautifully intricate and orderly" than the crustal zone of this planet.

Its intricacy has long been appreciated, as stratigraphy, paleontology, mineralogy, and other subdisciplines of classical geology followed their courses. How orderly it is, and indeed what nine-tenths of it is made of, are matters upon which we are getting our first solidly based views through the tools and methods of geophysics. The determination of the gross and the fine structures of this crustal zone and the unraveling of its tectonic and magmatic history are large objectives toward which a number of the geophysicists of the Institution contribute. The nature of these investigations, and the order of their significance, may be judged by samples from the year's work at the Geophysical Laboratory and the Department of Terrestrial Magnetism.

Two important immediate objectives of this joint activity of the Geophysical Laboratory and the Department of Terrestrial Magnetism have been a charting of the phase equilibria of a number of important mineral systems and a search for indicators that will be as accurate for the history of crystalline rocks as fossils and sedimentation sequences are for sedimentary rocks. For both objectives the laboratory synthesis of minerals under varying conditions of chemical composition, temperature, and pressure has given significant results. But the most important results for the second have come from the study of mineral sources of radioactivity—the now well known "nuclear clocks."

The primary methods for investigating phase equilibria among mineral systems rest upon the use of high-temperature, high-pressure equipment for synthesizing or metamorphosing minerals in the laboratory. One interesting consequence from employment of these methods during the year was the synthesis of diamonds from graphite by Boyd and England, making the Geophysical Laboratory one of the few places where this feat has been performed. The first well established report of diamond synthesis was made from the research laboratories of the General Electric Company in 1955. The synthetic product crystallized at the Geophysical Laboratory resembles natural "carbonado" diamonds used for industrial purposes. They were synthesized at pressures of 75 kilobars (75,000 atmospheres) and 1500°C (approximately 2750°F). The studies of the graphite–diamond inversion were undertaken to gain knowledge of the geological formations within which diamonds occur and of the contact catalysts needed for their synthesis.

Even though the synthesis of a rare mineral like diamond constitutes a striking feat, the Laboratory has stressed experiments with minerals thought to be very generally distributed in the earth's crust and mantle, and therefore particularly revealing of its structural history. The olivines are such a mineral series. Boyd and England during the year obtained a dense spinel form of the iron olivine fayalite in experiments using pressures between 60 and 80 kilobars. The results of these experiments, together with other data, suggest that the transition from fayalite to spinel occurs in about the same pressure-temperature range as the inversion from graphite to diamond. These experiments are

of particular interest because they furnish further evidence for the existence of a transition from natural olivine to spinel. This transition may be responsible for the marked seismic discontinuity known to exist at a depth of about 400 kilometers in the earth's mantle, and thus far not satisfactorily accounted for otherwise.

One mineral of widespread occurrence at the earth's surface is kyanite. Earlier experimental work had indicated that pressures necessary for its formation were substantially greater than those considered by geologists to be responsible for common metamorphic rocks in which kyanite is encountered. Professional skepticism therefore greeted these earlier laboratory results, and it became important to extend them. This was done during the year by S. P. Clark, who redetermined the equilibrium curve between kyanite and its polymorph, sillimanite. His new data suggest that a minimum pressure of 10 kilobars, corresponding to a depth within the earth of about 30 kilometers or more, presents the most likely condition for the stable formation of kyanite in nature, confirming the earlier laboratory work.

In another set of experiments Schairer of the Geophysical Laboratory is investigating the principal mineral systems influencing the nature of the source magmas (molten rock) from which the many types of igneous rock are formed. The materials selected for experiment are the normal minerals of basalt, including forsterite (an olivine), silica, nepheline, the feldspars albite and anorthite, and the pyroxenes diopside and enstatite. Data accumulated from experiments during the year on the albite–forsterite–silica series and the forsterite–nepheline–diopside series offer major contributions to a comprehension of the complex basalt system. This far-reaching program aims at the construction of a "flow sheet" in which the sequence of the main liquid courses of crystallization of basalt may be shown. Its initial successes suggest that the construction of such a flow sheet will be possible. The work of Hytönen has also contributed to an understanding of this system. He found that the alumina in pyroxene minerals has a significant role in the crystallization of basalt.

The search for an order to be found in the earth's mantle and in the past history of its evolution of course seeks principles of as wide applicability as possible. Each contribution to an understanding of phase equilibria in mineral systems builds in this direction. One such contribution during the year was also of unusual theoretical interest.

For several years a derivation from thermodynamic theory has been set forth as an explanation of some phenomena involved in the genesis of minerals in nature. This theory indicates that the formation of minerals of low molar volume is favored by high total pressure. It is known that minerals form in the presence of an impure vapor phase, the course of formation being affected by both the total confining pressure and the partial pressure of each reacting volatile component. This theory and its applicability to geology have been

points of controversy among petrologists, whose disagreement had not been resolved by earlier experiments. During the year Greenwood of the Geophysical Laboratory tested the theory by investigating the stability of analcite ($NaAlSi_2O_6H_2O$) in the presence of water–argon mixtures. The effect of total pressure on the stability of analcite as observed in the experiments was in close agreement with the stability predicted from thermodynamic theory. These results are significant because the theory is widely applicable to problems in metamorphic petrology. Metamorphic reactions occurring in the presence of other gas mixtures, such as water and carbon dioxide, can be treated in the same way as the analcite–water–argon system, and the separate effects of total and partial pressures can be evaluated.

Other interesting experiments have dealt with the behavior of ions within aqueous solutions in rocks. In one, Orville of the Geophysical Laboratory has found that when solutions containing alkali ions are simultaneously in contact with alkali feldspars at different temperatures potassium tends to migrate toward the low-temperature and sodium toward the high-temperature region. This behavior explains the known occurrence of potassium-rich feldspars in the wall rock adjacent to intrusive bodies of granite, and other puzzling differences in the potassium and sodium content of adjacent rocks. In another experiment Barnes and Ernst have examined the effect of ionization and of dissolved substances in geological fluids at supercritical temperatures and pressures. Preliminary results indicate that pressure-temperature curves for hydration reactions may be 70°C or more lower where sodium hydroxide is the solute than those where pure water is present.

In the search for geological age indicators of general use the most scientifically attractive thus far have been the five nuclear "clocks" described in previous years. It will be remembered from our earlier reports that all five clocks (involving the radioactive decay of uranium-lead, lead^{207}-lead^{206}, strontium-rubidium, potassium-argon, thorium-lead) recorded the same indicated age for ancient rocks under undisturbed conditions. Later it was found that the clocks in rocks that had gone through periods of mountain building sometimes disagreed substantially. Aldrich, Wetherill, and Bass of the Department of Terrestrial Magnetism and Tilton and Davis of the Geophysical Laboratory have continued to explore the characteristics of these clocks and the conditions for their accurate interpretation. It has now been established that long-term diffusion is a factor where discordant ages are shown by the different clocks, particularly in the lead^{207}/lead^{206} ratios found in zircon. The differential losses of lead^{207} and lead^{206} can be calculated from their diffusion characteristics, and a predicted pattern of consequent age discordances can be developed and compared with the discordances observed in natural rock. Analysis indicates that long-term diffusion has been an important factor in accounting for discordant ages as measured by uranium-lead "clocks" but has been less important in age

values determined by means of the other radioactive pairs. This information promises material assistance in resolving problems of age determination arising when, in situations where pronounced mountain building has occurred, there is a substantial lack of agreement among the various "clocks."

These experiments and others suggest that the "clocks" must be examined with the greatest possible care and thoroughness, including an accounting for variations in age patterns, if they are to be considered accurate indicators of age. There is a very real prospect that, through such means as these, answers can be found to three fundamental geological questions: Is the mineral-forming process continuous? Are there discrete epochs of tectonic activity interspersed with quiescent periods? To what extent are epochs of tectonic activity, if they do occur, simultaneous in all continents? The data now at hand suggest that significant epochs of tectonic activity may have occurred about 1000 million years ago and again about 2600 million years ago on nearly all continents.

A search for another type of geological indicator also met with considerable success during the year. Yoder and Chinner have been looking for a common sensitive piezometer (pressure indicator) for rocks formed under a wide range of conditions. Studies of almandite–pyrope–garnet series strongly suggest that the composition of the solid solutions formed may yield a sensitive measure of pressure if the temperature is known. A first step in pressure determination is calculation, with the aid of one of the known geothermometers, of the temperature at which the rock was formed. With this information at hand, Yoder and Chinner find that the pressure at which the minerals were formed can be learned from the composition of the garnet in the rock. Thus garnet promises to be a most useful piezometer for many rocks.

One of the most striking general aspects of the geophysical program at the Institution is its consistent design to uncover results that will be widely applicable. Knowledge of the phase equilibria in mineral systems obtained at the Geophysical Laboratory has repeatedly been applied to mineral associations from all the continents, and even to meteorites from outer space. Application of the Institution's geophysical work is likely to be extended even further in the future. Members of its staff currently participate in the planning of the national space research program and the Mohole project for probing into the earth's crust. As the Director at the Geophysical Laboratory has pointed out, exploration of the planets is certain to lead to additional application of the results already at hand, and must present us with new and important questions. The same will be true as new evidence on the nature of the deeper layers of the earth's crust is provided by specimens which will become available from extremely deep drilling. The staff of the Institution that is concerned with geophysical matters has been preparing for the interpretation of such data dur-

ing some years. A fascinating future appears to lie before the earth scientists no less than before the astronomers.

By contrast to the situation some years ago, the science of biology today is one of precision and elegant method. The advancing frontier in the life sciences lies in research where the ultracentrifuge, the electron microscope, isotopic tracers, and the concepts of molecular chemistry are commonplace tools and essential weapons. Perhaps more than in any other area of science the intermingling interests and methods of disciplines once considered discrete dominate the research scene. Physicists and chemists have joined their knowledge and their methods with those of biologists and medical research workers. The penetrating concepts which these methods are bringing to the life sciences are well illustrated in the biological program of the Institution, in genetics, in the study of the metabolism of cells, in developmental biology, in the study of the basic mechanisms of plant growth. Although the study of life processes is the dominant interest of three of our six departments, no less than five of them have been concerned in one way or another with significant experiments in that field during the current year.

In many of the technically advanced nations of the world experiments are being conducted on the physical and chemical nature of the storage and transfer of hereditary information from germinal or embryonic cells to the mature organism. The dominant view at the present day is that the sole carrier of hereditary information in most if not all organisms is deoxyribonucleic acid (DNA). As Hershey and his associates in the Department of Genetics have set forth in some detail later in this report, such a theory, taken together with modern concepts of the molecular nature of DNA, must imply that the bodily characters defining, for example, a species, are specified in a message written in at least two codes. One code is inviolate, and ensures the reproduction of unchanged DNA molecules during the multiplication of cells. Other codes serve as the templates for growth through precisely guided and normally irreversible stages which ultimately will produce the mature organism. An important part of this picture ascribes the synthesis of protein to the intermediate action of ribonucleic acid (RNA). Guided by a linear and specific sequence of bases in the DNA molecule, the RNA in turn directs the joining in a definite sequence of amino acids to make the proteins that are the building blocks of life.

All over the world, experimenters are probing for further evidence to confirm or revise this scheme. During the year two groups of research workers in the Institution have continued illuminating experimental programs to test and elaborate various aspects of the theory. Hershey and his associates in the Department of Genetics have used bacteriophage and their specific bacterial hosts as experimental media, while Roberts and his associates of the Biophysics Section in the Department of Terrestrial Magnetism have continued their study of metabolism in bacterial cells, particularly those of *Escherichia coli.*

The Biophysics Section of the Department of Terrestrial Magnetism has continued to center its attention on the structure and metabolic role of the ribosomes—those intracellular particles that appear to be so intimately and specifically connected with metabolism in bacterial cells. It will be remembered that the bacterial cell includes a nucleus with deoxyribonucleic acid (DNA), protein, and ribonucleic acid (RNA) content, "ribosomal" particles outside the nucleus containing RNA and protein, "nonparticulate" protein and RNA within the cell, and of course the cell wall. During the year Roberts and his colleagues found that ribonucleic acid (RNA) can be extracted from ribosomes in a manner that preserves hydrogen and magnesium bonds. A unit equivalent to the RNA in a large ribosomal particle was obtained. It was found that these large units could be artificially broken down into smaller ones. In this way structures one-twentieth to one-fortieth the size of the larger ribosomes were obtained. These 4S units, as they are named from their sedimentation rate, were isolated from living cells. They were found to occur naturally both in the ribosomes and in the nonparticulate fraction of the cells.

In an experiment employing radioactive tracers it was found that the small 4S units in the undifferentiated part of the cell are the first to be labeled. Similar units in the ribosomes come next, and finally the components of a large ribonucleic acid unit are labeled. The conclusion drawn is that the large ribosomal units are formed in the growing cell by assembly of the 4S subunits of RNA and associated protein. Thus the basic structural unit associated with protein and RNA synthesis within these cells may have been discovered.

Several other and related observations of significance were noted: (1) Ribosomal protein is similar in content to the soluble protein in the nonparticulate portions of the cell. (2) If present theories of the mechanism of genetic information transfer are correct, the small RNA subunits of the ribosomes are not large enough to serve as templates for the number of amino acids that occur in even the smallest protein chain of the cells. (3) An analysis of cell enzyme digests shows many nucleotide sequences, with a frequency indicating random distribution within the cell. These data suggest that there are many different kinds of RNA molecules. (4) Other previous work has indicated that early steps of ribosomal synthesis occur in the nucleus.

Although the hypothesis that information is transferred from DNA to RNA to protein is currently popular, there are difficulties in interpreting all the experimental data in terms of this model. Furthermore, the data do not exclude the alternative hypothesis that information may be transferred *directly from DNA to protein* during ribosomal synthesis. It may be this protein rather than RNA alone that subsequently specifies the amino acid sequence of protein synthesized by the ribosome. Such an hypothesis is sufficiently arresting to emphasize that further study of intracellular organization and metabolism is of primary importance to understanding how the molecules of life are built.

What can demand more wonderful precision than the examination and charting of the interior of a cell? But a challenge of equal demand and intricacy is offered by the structure of the interior of a virus particle. At the Department of Genetics, Hershey and his colleagues have been working with the bacteriophage known as T2, which infects *Escherichia coli,* in a series of elegant experiments searching for evidence of the structure of the DNA within the virus, and on its functions in phage metabolism within the infected bacterial cells. Using chromatography on a column of basic protein Burgi and Hershey have been able to identify half molecules and quarter molecules of phage DNA. They have found that the sedimentation coefficient and intrinsic viscosity of quarter molecules of DNA isolated by the column correspond to a molecular weight that they tentatively estimate to be about 13 million. This weight is calculated by projecting a calibration curve, based on light-scattering measurements, elaborated by Doty and his co-workers at Harvard University. If the estimate is correct, a particle of phage T2 contains two DNA molecules of the identical molecular weight of 50 million, rather than the ten molecules postulated in last year's report. One or both of these molecules must make up the phage chromosome.

By differentiating among phage proteins, tracing the course of development of these proteins, and sequentially inactivating DNA in phage particles with ultraviolet radiation, Hershey and his associates have obtained evidence that the formation of some proteins is at least linked with the development of phage DNA. They divide such "phage-specific" proteins into two classes, one represented by a hydroxymethylating enzyme for which synthesis commences less than two minutes after infection of the bacterium (class 1) and another represented by phage-coat protein for which synthesis begins seven minutes after infection (class 2). If infected bacterial cells are irradiated with ultraviolet light soon after infection, nucleic acid synthesis will fail but proteins of the first class will be formed within the infected cells. However, irradiation several minutes after infection does not prevent subsequent synthesis of class 2 proteins within the infected cells. This indicates that the synthesis of class 2 proteins depends on a modified DNA function that is not itself sensitive to ultraviolet light but can occur only after a cell contains relatively large amounts of phage-modified DNA at a particular developmental stage. For the synthesis of phage-coat proteins this point may come when the phage DNA derived from the infecting particle goes through a transition from the "extended" configuration it has within the bacterial cell to the condensed configuration it is thought to have within the completed phage particle.

Bacterial cultures infected with phage T2 exhibit a remarkable increase in resistance to radiation of the phage-producing ability of the cells during the first ten minutes or so after infection. By comparing the effects of chloramphenicol when added at various times between two and nine minutes after

the infection of bacteria with the T2 phage, Simon obtained evidence during the year that suggests a correlation of the evolution of this radiation resistance with the synthesis of DNA. The addition of chloramphenicol prevents protein synthesis totally, but inhibits DNA in a degree inverse to the time elapsed after infection. Simon found that, if the antibiotic is added two minutes after infection, the time at which ultraviolet light resistance normally begins to increase within the infected bacteria, no resistance develops. Radiation resistance does develop within the cells, however, if chloramphenicol is added later than two minutes after infection. The later the addition of chloramphenicol up to the maximum of nine minutes, the higher the rate of increased resistance. Thus the effect of the chloramphenicol on the rate of development of resistance is very similar to its effect on the rate of DNA synthesis, and cannot be correlated with its effect on protein synthesis. This evidence is considered to be of particular interest because the belief has been held in some quarters that genetic information initially carried by DNA might be transferred to radiation-resistant structures other than DNA, like protein, to account for the phenomenon of increased radiation resistance.

The effects of radiation upon the materials of heredity have been the subject of much more than laboratory concern in the last several years. Warnings also have been voiced about the possible effects of the variety of chemicals that man has introduced into his environment in modern times. The recent research of Kaufmann and his co-workers of the Department of Genetics suggests that even mild chemical agents of cellular origin have mutagenic activity. They have found that the enzyme deoxyribonuclease (known from earlier work to be a "dissolving" agent for DNA) is mutagenic to fruit flies (*Drosophila melanogaster*) under laboratory conditions. Treatment of larvae and imagoes with deoxyribonuclease produced both recessive and dominant lethal effects and chromosomal rearrangements in the flies. Even though great care must be used in extrapolating these results to other organisms, they do underscore the great complexity of the problems of mutagenesis.

The ingenuity of recent laboratory techniques and the extent of the contributions of modern medical research to the study of developmental biology are vividly illustrated in the results obtained during the year by Dr. Ramsey of the Department of Embryology and her associates. Ramsey has been interested for some time in the circulation of blood within the maternal placenta. Over the past several years she has developed the hypothesis that arterial blood enters the placenta from the endometrial arteries under a pressure sufficiently high to drive it through the intervillous space and toward the chorionic membrane of the fetus. Physiological studies had earlier given indirect evidence of pressure gradients and other consequences of the hypothesis. Direct evidence, however, was lacking until the techniques of rapid serial radiography and cinéradiography were employed in experiments this year. Radiopaque dyes

were injected into the femoral arteries of anesthetized pregnant rhesus monkeys. The course of the dyes was followed until they entered the uterine arteries and finally the intervillous space of the placenta. Observations were achieved by rapid serial X-ray photographs or by cinéradiography. In the latter procedure a moving-picture camera is used to photograph the X-ray image on the screen of a television monitor. The resulting films show with great clarity the characteristic spurts of blood as the dye enters the intervillous space, as predicted by Ramsey's hypothesis. These experiments were carried out in cooperation with the Department of Radiology, Johns Hopkins Hospital, whose Director designed the X-ray photography equipment.

The present program of the Department of Embryology is particularly well typified by the work of Ebert and DeLanney. It lies essentially in the domain of molecular biology, involving the careful and accurate advancement of our knowledge of immune reactions. During the year Ebert and DeLanney have completed a major program in which they have used chicken spleen to study the properties of immunologically competent tissues. As the work has progressed it appears that the effects of grafts not only embrace a graft-versus-host reaction but also definite reactions on the part of the host. In the course of the year they have successfully resolved problems of the relative contribution of donor and host cells. Ebert, Mun, and Tardent (a Rockefeller Foundation Fellow) have traced the course of cells emanating from spleen grafts labeled with tritiated thymidine within embryonic chick hosts. By the eighth postoperative day radioactive cells could no longer be detected in the graft. Also, none were clearly detectable within the enlarged host spleens. A subsequent experiment by Errico, Mun, and Ebert employing repeated serial grafting of embryonic spleen, however, did establish the fact that a very small number of embryonic cells from the graft enter the host spleen, where they are capable of maturing. This cellular contribution to the later immunological reaction is thus small, but significant. Ebert concludes tentatively that the cells of both donor and host may contribute to the spleen reaction, the host cells playing the predominant role numerically. The cells associated with the normal growth processes in an organism would therefore appear to dominate the immune reaction rather than cells from the donor tissue.

The staff of the Institution is deeply concerned with developmental biology not only in the animal but also in the plant world. Algae have long been a subject of attention for the Department of Plant Biology as it has explored the intricacies of the photosynthetic process; now they have also become a subject of investigation for the Geophysical Laboratory, which during the year commenced an interesting series of experiments on the paths of carbon assimilation in algae, using methods of isotopic analysis.

Past investigations of the Department of Plant Biology on the occurrence and function of chlorophyll *a* have established the participation of specific

forms of chlorophyll in two separate photochemical reactions in photosynthesis. One of these reactions is driven by the form of chlorophyll *a* having its red absorption peak at 695 mμ. The other is driven by either chlorophyll *b* or the 673-mμ absorption form of chlorophyll *a*. The complementary function of chlorophyll *a* 673 and chlorophyll *a* 695 was found in several algae lacking chlorophyll *b*.

The enhancement obtained by simultaneous illumination of two complementary pigments was found to disappear in *Chlorella* depleted of phosphate. It returns after addition of pyrophosphate. This experiment of McLeod is the basis for the conclusion that the photophosphorylation reaction and the formation of reducing power, two well known parts of the photosynthetic process, are driven by separate pigments.

By contrast with green plants, experiments with the algal genus *Phormidium* showed that the pigment phycoerythrin increased efficiency of light absorbed not only by chlorophyll *a* 695 but also by the other forms of chlorophyll *a*. Furthermore, excitation of the phycoerythrin pigment by light of differing wavelengths indicated that there are at least two different pairs of mutually enhancing pigments.

A new technique was used during the year that facilitated the detection of the several forms of chlorophyll *a*. By measuring derivative absorption spectra at −180°C the bands of the separate pigment forms are greatly sharpened.

A particularly striking consequence of the duality of the photochemical system is seen in the action spectrum for *Chlorella* photosynthesis when measured at high light intensity. Such spectra have a structure with distinct peaks at 650 mμ and 440 mμ. This is important evidence to contradict a prevailing hypothesis that at saturating light intensities all wavelengths have the same photosynthetic efficiency. Instead, it appears that a maximum rate of photosynthesis is reached only when the two photochemical reactions initiated by the two pairs of interdependent pigments are proceeding in the correct ratio.

In an especially interesting experiment Abelson and Hoering of the Geophysical Laboratory have produced some arresting evidence that conventional photosynthesis leading to carbohydrates may not be the only pathway through which the carbon dioxide of the atmosphere is assimilated by the green plant. Their study started with the relatively well known fact that the lightest isotope of carbon tends to be preferentially fixed when inorganic carbon is converted into living matter. The carbon 12/carbon 13 ratio is thus higher in organic carbon than in limestone carbon or in carbon dioxide present in the atmosphere. Abelson and Hoering raise several fundamental questions of great scientific interest which follow from this phenomenon. Among them are: Is this isotope fractionation characteristic of all living matter? Do significant differences in isotope abundances exist among specific compounds? And, if such differences exist, can they be related to known biochemical processes?

With these and other questions in mind Abelson and Hoering have begun to examine the distribution of the stable isotopes of carbon in living material. Their first effort has been devoted to the study of the green alga *Chlorella pyrenoidosa,* from cultures of which amino acids were isolated and their carbon isotope composition examined. The amino acids were chosen for analysis because of their biochemical importance and because excellent methods are available for their isolation. The results are of considerable interest. They showed that some of the amino acids, such as leucine and valine, have isotope ratios similar to those in the lipide fractions of the plants; that is, they contain markedly less carbon 13 than is present in the inorganic environment. Other amino acids, like serine, proved to have ratios much closer to the inorganic carbon dioxide used as input for the experiments.

Even more significantly, the carboxyl carbons of all chains were heavier; that is, they contained a higher proportion of carbon 13 than the remainder of the carbon chains of the amino acids. This point is of particular interest, because it was previously shown at the Department of Terrestrial Magnetism by Roberts, Abelson, and others that in *Escherichia coli* there is a direct incorporation of carbon dioxide into the carboxyl group of glutamic and aspartic acids and into the guanidine group of arginine. In these earlier experiments carbon 14 tracers showed a common point of entry for carbon dioxide into the bacterial cells, namely, condensation with pyruvate and subsequent synthesis in a Krebs cycle.

The year's study of *Chlorella* strongly suggests that a similar situation holds for it and probably other photosynthetic organisms. Abelson and Hoering believe that the results obtained by examining carbon 12/carbon 13 ratios of aspartic acid, glutamic acid, and arginine in *Chlorella* are interpretable through comparative biochemistry. They argue that living systems have invented only a limited number of pathways, and that these have broad general application. The synthetic pathways of the three amino acids in *Chlorella pyrenoidosa* seem very similar to those in *Escherichia coli* and other organisms. There appear to be at least three pathways by which carbon dioxide is incorporated in *Chlorella:* condensation with ribulose diphosphate, the Krebs cycle pathway, and one leading to the guanadine carbon of arginine.

If it can be assumed that the isotope abundance found in the lipides or in the noncarboxyl portion of aspartic or glutamic acids in *Chlorella* is characteristic of the fixation of carbon dioxide in carbohydrates, the result is a most significant conclusion: a considerable fraction of the carbon fixed in *Chlorella* is incorporated by pathways other than those traditionally described for photosynthesis. The potential bearing of this upon our knowledge of plant growth and biochemical evolution is obvious.

The program of the Institution in the life sciences, of which only a relatively few representative experiments have been included in this review, well

illustrates the strategy of unfolding the "beautifully intricate and orderly world" of life. The greater part of the efforts of the Institution in the biological sciences at present are concentrated in investigations at the molecular and cellular levels. This is where many of the most significant investigational challenges now lie. At the same time the larger problems of more complex organic systems and even of populations of systems are not forgotten, as is demonstrated by such work as that in developmental biology already described. As Hershey notes elsewhere in this report, "No scheme can be tested short of learning the details of its operation. This is evidently a task for generations of biologists. We report . . . what we hope is perceptible progress." One may add that it is progress which includes some of the most fascinating and skillful detective work in the modern world.

At the beginning of this review, brief mention was made of the present close relation between science basic and science applied. The equipment of every laboratory devoted to fundamental research these days provides examples of the important, and even essential, symbiosis between basic and applied science, whether it be in the great variety of fine chemicals at hand, in the presence of recording equipment of great sensitivity and versatility, or in such specialized instruments as the ultracentrifuge or devices for maintaining pyrogenic temperatures. For many years the program of the Institution has illustrated particularly well the meaning of this relation. Indeed, it has illustrated not only the close relation between science and science applied but also the fruitful cooperation sometimes possible in science between governmental and private institutions. A particularly good example has been the operation of the Committee on Image Tubes for Telescopes, a cooperative project of the Mount Wilson and Palomar Observatories and the Department of Terrestrial Magnetism of the Institution, and the Lowell Observatory, the National Bureau of Standards, and the United States Naval Observatory. Several commercial companies have participated in the program both by contract and by professional consultation, including the RCA Electron Tube Division, the ITT Laboratories, the Westinghouse Electric Corporation, the Allen B. Du-Mont Laboratories, and others. Technical problems of a high order are encountered in the development of image tubes, and the participation of the several great industrial research laboratories has been vital to the success achieved.

It was reported last year that development had approached the stage where some application of the tubes to astronomical observation could be predicted. During the current year, the work of the Committee has reached a point of real application to research astronomy. The Committee now has at its disposal special tubes for astronomical use that have proved thirty to sixty times more sensitive than photographic plates in a few special applications. Because the devices at present available have inherent difficulties of resolution (granu-

larity) and background fog that limit their employment, discovery of situations where they do have special advantage, and a search for improved devices, have been of current interest. Two uses in astronomy have been found for these tubes, even in their present stage of development, where they yield considerable observational advantage.

Cascaded image intensifiers manufactured by RCA have been employed to record images of close double stars that cannot be resolved by any other photographic technique. Fredrick of the Lowell Observatory has measured with precision the separation of the visual binary 51 Aquilae, which has a separation of about 0.46 second of arc; in previous photographic resolution a separation of less than 1.5 seconds has been rare.

Mica window tubes, developed by the ITT Laboratories, have been used to explore the region of infrared stellar spectra at around 1 micron, a spectral region relatively inaccessible by ordinary photographic techniques. Fredrick has undertaken a program of observing several long-period variable stars in the 1-micron region. It is possible that such observation may prove an important tool for measuring temperature differences in stellar atmospheres.

In addition, some testing was undertaken of tubes using secondary electron multiplication which have been under development for several years at the Westinghouse Research Laboratories. Relatively high resolutions have been demonstrated with these tubes in the laboratory—higher in fact than with any other type of tube. It is thought that with further technical improvements providing greater contrast and eliminating spurious emission these devices may be extremely useful for spectroscopic work. Thus, though additional problems undoubtedly lie before the Committee and its participating contractors, the events of the year have demonstrated sound progress on their part toward a real advance in research technique as well as in application to astronomy.

It is satisfying to report also that the Institution has shared significantly in the national effort to support scientific effort and science institutions abroad. Indeed, we are no strangers in this area, since our programs in archaeology and in terrestrial magnetism long maintained important field stations abroad, and our fellowship and grants program has had a long succession of foreign recipients. During the year seventeen Fellows from nine foreign countries were resident and participated in the research of our departments. The work of nearly all of them is recognized in the individual reports that follow this review. In addition, the Institution took the initiative in obtaining a continuation of the distinguished visitor program of the International Geophysical Year. A grant from the National Science Foundation, supplemented by Institution funds, has either brought or scheduled sixteen geophysicists from eleven countries for visits of three to fourteen months at laboratories and research establishments in the United States, including our own. In this program, which has been directed by the Department of Terrestrial Magnetism, foreign

guests were invited to write their own itineraries. These invitations apparently have combined to make a highly successful demonstration that the United States has participated in the International Geophysical Year on a truly international basis.

The Institution continues to be interested in the building of the physical sciences in South America, particularly through the program of the Department of Terrestrial Magnetism. Wells of that Department has become Scientific Attaché for southern Latin America, stationed at Rio de Janeiro. During his two-year leave of absence it is expected that he may be able to do much to stimulate interest in radio astronomy and radio propagation in that area of the world.

Duplicates of the Department of Terrestrial Magnetism extended antenna arrays for studying the radio emissions of the sun have been provided to DTM collaborators in Chile, Argentina, and Uruguay. Finally, Institution funds and National Science Foundation funds have been made available to build in South America a duplicate of the equatorially mounted parabolic antenna installed at the Department of Terrestrial Magnetism in 1952. The "parent" instrument has been used for the survey of hydrogen clouds among the stars of our galaxy, a program that was shifted to the new 60-foot parabola during the year. The South American installation will probably be located in the vicinity of Buenos Aires.

It seems appropriate to end this review with brief mention of the meaning of uncommitted research. We believe that one of the greatest assets of Carnegie Institution is the freedom an individual staff member can feel to undertake research on any subject, regardless of his past interests. One vivid current example has been the work of Chayes of the Geophysical Laboratory during the year.

Chayes is a petrologist, but elsewhere in this volume will be found a report from his laboratory entitled "Correlation in Closed Tables," a contribution in the statistical field of correlation analysis. This investigation was stimulated by certain problems in petrography, but in it Chayes has reached a number of novel and potentially useful conclusions applicable to the statistical analysis of data obtained in many branches of experimental science.

Chayes notes that a large part of scientific inquiry is aimed at discovering whether or not relations between two or more variables of a complex assemblage are random, as, for example, between birth weight and growth rate of living organisms, or between hardness and chemical composition of alloys. Numerical analysis to discover the existence of these relations usually takes the form of calculating total or partial correlation, followed by tests of the significance of these correlations. However, if the sum of variables in each statistical item of a sample is the same for all items, the assumptions underlying traditional correlation analysis are invalid. These are "closed arrays";

Chayes's study treats correlation statistics within them. With the assistance of machine computation he is planning to carry this study further, investigating next experimentally closed arrays resembling those actually encountered in nature.

As always, this summary can report only a relatively small proportion of the many investigations undertaken by our six departments during the current year. They have been chosen not only because they are representative of the work of the Institution in each of its fields but also because they reflect Institution interests in the trends of American science at large. Such condensation, essential as it is, must always be in some measure arbitrary and difficult. It is well epitomized by a remark made by Dr. Emile Roux, a famous director of the Pasteur Institute, to his colleagues at the twenty-fifth anniversary of the founding of that institution. He must be excused, he said, "for presenting in such a summary fashion research work which had cost them so much trouble and care."

Losses . . .

Once again, and as always with much regret, I report the retirement of some senior Staff Members of the Institution. Dr. Milislav Demerec, Director of the Department of Genetics since 1943, Dr. Rudolph L. Minkowski, Staff Member of the Mount Wilson and Palomar Observatories since 1937, Dr. Joseph W. Greig, petrologist at the Geophysical Laboratory since 1922, and Mr. Earle B. Biesecker, Bursar of the Institution since 1941, all retired on June 30, 1960. Each of these men will be greatly missed.

Dr. Demerec joined the Institution as a Resident Investigator in the Department of Genetics in 1923, commencing his long and highly productive research career at Cold Spring Harbor. His interest and achievement in research never flagged, even though his administrative load became increasingly heavy after 1936, when he was appointed Assistant Director of the Department. In 1941 the post of Director of the Biological Laboratory of the Long Island Biological Association, which adjoins the Institution laboratory at Cold Spring Harbor, was added to his administrative duties. He became Director of the Department of Genetics in 1943. Largely as the result of Dr. Demerec's drive and organizing ability, the summer Symposia at Cold Spring Harbor have become world famous and may truly be said to have had a significant influence on the course of modern biology.

Dr. Demerec's lifelong research has been directed toward elucidating the structure, the function, and the mutability of genes. His earliest studies were in maize genetics, but he is perhaps best known for his work on mutagenesis, his significant wartime researches on the biological production of penicillin, and, especially, for his most recent investigations of the "fine structure" of bacterial

chromosomes, using the criteria of biosynthesis and applying the methods of transformation, and particularly of transduction by bacteriophages. The high-yielding mutant strain of *Penicillium notatum* which he developed during the second World War has displaced previously used strains in the commercial production of penicillin.

After the war Dr. Demerec concentrated his research primarily in bacterial genetics, adding critically to our knowledge of the chromosome structure especially of the bacteria *Escherichia coli* and *Salmonella typhimurium*. Results of Dr. Demerec's studies during the current year are described in this report. In recent work, in which he has studied gene loci controlling the synthesis of specific amino acids in *S. typhimurium,* he has been able to distinguish multiple mutation sites within single "gene loci."

Dr. Demerec will carry forward his active research without interruption. He has been appointed a senior Staff Member of the Biology Group at the Brookhaven National Laboratory, and it can be predicted that his program will continue in all its present activity and significance for years to come.

Dr. Rudolph Minkowski came to the Mount Wilson Observatory from Germany in 1935, and ever since that time has contributed continuously and most significantly to stellar astronomy. He is especially well known for his studies of gaseous nebulae. During his career, indeed, he more than doubled the known number of such astronomical objects. He also studied the velocities and internal motions of near-by galaxies, and has obtained some notably long sequences of spectra of supernovae, adding greatly to our knowledge of these stars.

In collaboration with Dr. Walter Baade, Minkowski pioneered in the optical identification of strong sources of radio emission in space. He provided evidence that some of these radio sources, as in Cygnus A, actually constitute galaxies in collision. This has proved to be true of the cluster of galaxies discovered optically this year by Minkowski, a cluster that is the most distant object in the universe whose spectra have been photographed and analyzed.

Dr. Joseph Greig was a petrologist at the Geophysical Laboratory for thirty-eight years. He devoted his attention especially to studies of phase equilibria in mineral systems, a subject of great importance in geophysical research. An outstanding contribution was his comprehensive study of liquid immiscibility in silicate systems. His studies of the equilibrium relations between ferric oxide, ferrosoferric oxide, and oxygen have provided a basis for interpreting the occurrence of iron oxides in nature. His joint study with T. F. W. Barth of the nepheline–albite system has assisted greatly in the geological interpretation of relations between feldspathoid and feldspar minerals. At the time of his retirement he was preparing a comprehensive report on the copper–iron–sulfur system, which will treat the theory of coexisting ternary solid solutions.

Dr. Greig's research has had several practical applications. His studies of

silicate systems led to the development of low-alumina, low-alkali silica brick, and they have given information of considerable importance in studying the reaction between metallurgical slags and refractories in furnace operation. His ferrosoferric oxide study was especially useful for improvements in the manufacture of steel.

The long and devoted service of Earle B. Biesecker spanned a significant period of reorganization in the financial management of the Institution. During the twenty-seven years of his service, the responsibilities of his office became much enlarged and increasingly exacting, in consequence of the adoption by the Institution of a collective insurance program, the extension of Social Security and Group Hospitalization benefits to the Staff, the establishment of the Institution's independent Retirement Plan, and significant changes in investment policy. He introduced a modern auditing system into Institution practices, and standardized the accounting procedures of the Departments. He drafted the first manual of fiscal procedures used by the Institution, and brought in the mechanization of payroll accounting. His careful analyses of the financial aspects of many administrative problems were appreciated by every officer of the Institution having administrative responsibilities. He had an important part in the development of the new Retirement Plan, and he served as Treasurer of the Retirement Fund of the Plan from the initiation of the office in 1954 until this year. His wise counsel, his conscientiousness, and his friendliness will be missed by all who were privileged to associate with him.

It is with a deep sense of loss that I must report the deaths of one former Trustee, six retired Staff Members, and one Fellow.

William Cameron Forbes, former Trustee, died on December 24, 1959, at age 89, after a distinguished career in the public service. During his thirty-five years as a Trustee of the Institution (1920–1955) he accepted many important special responsibilities. He was Secretary of the Board from 1922 to 1930, Vice-Chairman from 1935 to 1937, and Chairman from 1937 to 1945. He was a member of the Executive Committee from 1922 to 1930 and from 1932 to 1947, serving as its Chairman from 1935 to 1945. During his long and active career he occupied high public office, including that of Governor General of the Philippines, to which post he was appointed by President Taft.

Dr. John A. Anderson, noted for his development of instruments for astronomical research, died on December 2, 1959, at age 83. He joined the staff of the Mount Wilson Observatory in 1916, retiring in 1943. Having devised methods for ruling extremely fine spectroscopic gratings, he was at once placed in charge of constructing a large ruling engine when he came to the Observatory. After World War I he developed the exploding-wire techniques for producing extremely high temperatures and, with Sinclair Smith, various auxiliary

devices, including the rotating-mirror camera, the rotating-mirror spectrograph, and the Kerr cell shutter, for studying the explosions. These methods and devices were employed during World War II in programs for the development of nuclear weapons.

As Executive Secretary of the Observatory Council created to supervise the construction of the Hale Telescope, Dr. Anderson carried a great weight of responsibility for all phases of designing and constructing the 200-inch instrument on Palomar Mountain. He was a member of the National Academy of Sciences and of professional societies in the several fields of his broad scientific interest—astronomy, seismology, physics, and chemistry.

Dr. Ralph E. Wilson, Staff Member of the Mount Wilson and Palomar Observatories, who retired in 1951, died in Pasadena on March 25, 1960, at age 73. Dr. Wilson was primarily concerned with research on the motions of stars. He took a leading part in preparing the classic *Boss Catalogue,* which furnished the precise positions and motions of 33,342 stars for the epoch 1950. His last publication, *General Catalogue of Stellar Radial Velocities,* issued in 1953, contains the positions, magnitudes, spectral types, and definitive radial velocities of all stars whose velocities had been determined at the Observatories and elsewhere. A total of 15,105 stars is included, and proper motions are listed for 90 per cent of them. Astronomers concerned with stellar motions and galactic structure have found the *Catalogue* an indispensable tool in their studies. Dr. Wilson was a member of several astronomical and scientific societies and received the Gold Medal of the Danish Academy of Sciences in recognition of his work.

Dr. Arthur L. Day, Director of the Geophysical Laboratory from its beginning in 1907 until his retirement in 1936, died on March 2, 1960, at age 90. The Laboratory was the first of its kind in the world to be set up for the systematic study of rock formation, and through Dr. Day's efforts petrology was established as a quantitative science. Dr. Day bequeathed his entire scientific library to the Geophysical Laboratory, where it will be kept as a fitting memorial to his early leadership of the program.

Concurrently with his Directorship of the Department, Dr. Day was a Vice-President of the Corning Glass Works between 1919 and 1936. He had previously had the important responsibility of supervising optical-glass production in this country during the first World War. He was a member of the National Academy of Sciences and a past president of the Geological Society of America.

The death of Dr. Walter Baade on June 25, 1960, at Göttingen, Germany, is a loss that the Institution feels most keenly since he had planned to visit at the Observatories during this year. Dr. Baade retired in 1958, after twenty-seven years during which his distinguished work developed the basis for current theories on the evolution of stars, and provided us with our present concepts of the scale of distances in the universe. Dr. Baade first distinguished

two general types of stellar populations in galactic formations, which he designated Population I (blue giants) and Population II (red giants). He found the first most plentiful in the arms of spiral galaxies, while the second predominate in the nuclei of some galaxies. Deductions from this discovery led to important new concepts of the nature of stellar evolution. He recalibrated the cepheid variable stars, increasing their precision as indicators of stellar distances beyond the Milky Way. This recalibration established the fact that such distances must be considered to be at least twice as great as had previously been estimated. Dr. Baade also collaborated in first identifying optically several of the more distant celestial sources of radio emission, among them the galaxies in collision in Cygnus A, already mentioned, and a supernova in Cassiopeia.

After his retirement Dr. Baade served as visiting professor of astronomy at Harvard College, then at the Australian National University at Canberra, and finally at Göttingen University in Germany. Among Dr. Baade's many academic honors was the Gold Medal of the Royal Astronomical Society.

Dr. Frank C. Kracek, physical chemist at the Geophysical Laboratory from 1923 until his retirement in 1956, died in Washington, D. C., on July 5, 1960, at age 69. Dr. Kracek's investigations were concerned with the phase equilibria and thermal chemistry of silicates and sulfides and with the effect of pressure on phase equilibria. During World War II he carried on ballistic research for the National Defense Research Committee. After his retirement from the Institution he continued his work in thermal chemistry at the Geophysical Branch of the U. S. Geological Survey.

Mr. Karl Ruppert, a member of the Institution's former Department of Archaeology for nearly thirty-two years, died in Rochester, Minnesota, on August 13, 1960, at age 64. He had retired on October 1, 1956. Mr. Ruppert took an active part in the excavation and restoration of Maya buildings at Chichen Itza in Yucatan. In 1947 he was in charge of a joint Carnegie Institution and United Fruit Company expedition to Bonampak, Chiapas, Mexico, the archaeological site now famous for its mural paintings by the Maya Indians. The location of the site, the history of its discovery, and its architecture are all ably described by Ruppert in *Bonampak, Chiapas, Mexico,* written in collaboration with J. E. S. Thompson and Tatiana Proskouriakoff and published by the Institution in 1955. When the Department of Archaeology in 1950 began its survey of the last important center of aboriginal Maya civilization, the ruins of Mayapan, Mr. Ruppert worked with A. L. Smith on the survey of the site and excavations in many nonceremonial buildings. He spent much of his time during the last few years before his retirement in ordering and analyzing the data collected at Mayapan.

Dr. Colin Stanley Gum, a Research Officer of the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, and Fellow of the Mount Wilson and Palomar Observatories

for the year beginning August 1, 1959, died in an accident in Zermat, Switzerland, on April 28, 1960. He was in Europe at the time working on plans for a new Australian telescope. During the three years that Dr. Gum was at the Radiophysics Laboratory he participated in a 21-cm survey of the southern Milky Way and later interpretation of data from it. He also played a major role in research that led to the recommendation of a new system of galactic coordinates, largely based on 21-cm data. Dr. Gum was a Fellow of the Royal Astronomical Society and a member of the International Astronomical Union and the American Astronomical Society. His loss is keenly felt in the United States as well as in Australia.

. . . *and Gains*

Mr. Garrison Norton, President of the Institute for Defense Analyses of Washington, was elected a Trustee during the year. Mr. Norton comes to the Board with a most distinguished record of public service. Before undertaking the Presidency of the Institute, an interuniversity organization which assists the Department of Defense, Mr. Norton served as Assistant Secretary of State (1945–1949), as Director of the Export-Import Bank (1948–1949), as Deputy Director of the International Bank and Monetary Fund (1948–1949), as Consultant to the Secretary of the Air Force (1951–1955), and as Assistant Secretary of the Navy for Air (1956–1959). During the second World War Mr. Norton was a naval aviator in the American and European theaters, ending the war with the rank of Captain. Before the war he was associated with Arthur Young and Company, Accountants, in New York, becoming a general partner of that firm after 1930. He also was a special partner in the investment firm of William A. M. Burden and Company, New York, between 1949 and 1952.

I am especially glad to report that Dr. Philip H. Abelson, the Director of the Geophysical Laboratory, has been appointed by the President of the United States to the nine-member General Advisory Committee of the Atomic Energy Commission for a term of six years. This post is one of high significance in guiding the atomic program of the nation, both in matters of defense and in the development of atomic energy for peaceful purposes.

It is also my particular pleasure to report that Dr. Olin C. Wilson of the Mount Wilson and Palomar Observatories was elected during the year to the National Academy of Sciences.

Three astronomers in the Institution have assumed chairmanships of important professional committees during the year. Dr. Ira S. Bowen, Director of the Observatories, was elected Chairman of Section D of the American Association for the Advancement of Science; Dr. William A. Baum was appointed Chairman of the Committee on Astronomy, Advisory to the Office of Naval Research, and Dr. Armin J. Deutsch, Chairman of the Advisory Board for the National Radio Observatory at Green Bank, West Virginia.

Scott E. Forbush of the Department of Terrestrial Magnetism was elected an honorary professor of the University of San Marcos, Lima, Peru.

Caryl P. Haskins

PRESIDENT and TRUSTEES

TRUSTEES *Continued*

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FORMER PRESIDENTS and TRUSTEES

PRESIDENTS

Daniel Coit Gilman, 1902–1904
Robert Simpson Woodward, 1904–1920
John Campbell Merriam, *President* 1921–1938; *President Emeritus* 1939–1945
Vannevar Bush, 1939–1955

TRUSTEES

Alexander Agassiz	1904–05	Seth Low	1902–16
George J. Baldwin	1925–27	Wayne MacVeagh	1902–07
Thomas Barbour	1934–46	Andrew W. Mellon	1924–37
John S. Billings	1902–13	Roswell Miller	1933–35
Lindsay Bradford	1940–58	Darius O. Mills	1902–09
Robert S. Brookings	1910–29	S. Weir Mitchell	1902–14
John L. Cadwalader	1903–14	Andrew J. Montague	1907–35
William W. Campbell	1929–38	William W. Morrow	1902–29
John J. Carty	1916–32	William Church Osborn	1927–34
Whitefoord R. Cole	1925–34	James Parmelee	1917–31
Frederic A. Delano	1927–49	Wm. Barclay Parsons	1907–32
Cleveland H. Dodge	1903–23	Stewart Paton	1916–42
William E. Dodge	1902–03	George W. Pepper	1914–19
Charles P. Fenner	1914–24	John J. Pershing	1930–43
Homer L. Ferguson	1927–52	Henning W. Prentis, Jr.	1942–59
Simon Flexner	1910–14	Henry S. Pritchett	1906–36
W. Cameron Forbes	1920–55	Gordon S. Rentschler	1946–48
James Forrestal	1948–49	David Rockefeller	1952–56
William N. Frew	1902–15	Elihu Root	1902–37
Lyman J. Gage	1902–12	Julius Rosenwald	1929–31
Cass Gilbert	1924–34	Martin A. Ryerson	1908–28
Frederick H. Gillett	1924–35	Theobald Smith	1914–34
Daniel C. Gilman	1902–08	John C. Spooner	1902–07
John Hay	1902–05	William Benson Storey	1924–39
Myron T. Herrick	1915–29	Richard P. Strong	1934–48
Abram S. Hewitt	1902–03	William H. Taft	1906–15
Henry L. Higginson	1902–19	William S. Thayer	1929–32
Ethan A. Hitchcock	1902–09	James W. Wadsworth	1932–52
Henry Hitchcock	1902–02	Charles D. Walcott	1902–27
Herbert Hoover	1920–49	Frederic C. Walcott	1931–48
William Wirt Howe	1903–09	Henry P. Walcott	1910–24
Charles L. Hutchinson	1902–04	Lewis H. Weed	1935–52
Walter A. Jessup	1938–44	William H. Welch	1906–34
Frank B. Jewett	1933–49	Andrew D. White	1902–03
Samuel P. Langley	1904–06	Edward D. White	1902–03
Ernest O. Lawrence	1944–58	Henry White	1913–27
Charles A. Lindbergh	1934–39	George W. Wickersham	1909–36
William Lindsay	1902–09	Robert S. Woodward	1905–24
Henry Cabot Lodge	1914–24	Carroll D. Wright	1902–08

Under the original charter, from the date of organization until April 28, 1904, the following were ex officio members of the Board of Trustees: the President of the United States, the President of the Senate, the Speaker of the House of Representatives, the Secretary of the Smithsonian Institution, and the President of the National Academy of Sciences.

STAFF

MOUNT WILSON AND PALOMAR OBSERVATORIES

813 Santa Barbara Street, Pasadena 4, California

Ira S. Bowen, *Director;* Horace W. Babcock, *Assistant Director*

Halton C. Arp
William A. Baum
Armin J. Deutsch
Jesse L. Greenstein
Fred Hoyle
Robert P. Kraft
Rudolph L. Minkowski [1]
Guido Münch
J. Beverley Oke
Allan R. Sandage
Maarten Schmidt
Olin C. Wilson
Fritz Zwicky

GEOPHYSICAL LABORATORY

2801 Upton Street, N.W., Washington 8, D. C.

Philip H. Abelson, *Director*

Francis R. Boyd, Jr.
Felix Chayes
Sydney P. Clark, Jr.
Gordon L. Davis
Gabrielle Donnay
Joseph L. England
Joseph W. Greig [1]
Thomas C. Hoering
Gunnar Kullerud
J. Frank Schairer
George R. Tilton
Hatten S. Yoder, Jr.

DEPARTMENT OF TERRESTRIAL MAGNETISM

5241 Broad Branch Road, N.W., Washington 15, D. C.

Merle A. Tuve, *Director*

L. Thomas Aldrich
Ellis T. Bolton
Roy J. Britten
Bernard F. Burke
Dean B. Cowie
John W. Firor
Scott E. Forbush
W. Kent Ford, Jr.
Norman P. Heydenburg
Richard B. Roberts
Georges M. Temmer
Harry W. Wells
George W. Wetherill

[1] Retired June 30, 1960.

DEPARTMENT OF PLANT BIOLOGY

Stanford, California

C. Stacy French, *Director*

Jeannette S. Brown
William M. Hiesey
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Malcolm A. Nobs
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DEPARTMENT OF EMBRYOLOGY

Wolfe and Madison Streets, Baltimore 5, Maryland

James D. Ebert, *Director*

David W. Bishop
Bent G. Böving
Robert K. Burns
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Elizabeth M. Ramsey
Mary E. Rawles
Royal F. Ruth

DEPARTMENT OF GENETICS

Cold Spring Harbor, Long Island, New York

Milislav Demerec, *Director* [1]

Elizabeth Burgi
Helen Gay
Alfred D. Hershey
Berwind P. Kaufmann [2]
Ernest L. Lahr
Barbara McClintock
Margaret R. McDonald
George Streisinger

[1] Retired June 30, 1960.
[2] Acting Director, July 1, 1960.

OFFICE OF ADMINISTRATION

1530 P Street, N.W., Washington 5, D. C.

Caryl P. Haskins
President

Paul A. Scherer [1]
Executive Officer

Edward A. Ackerman
Executive Officer [2]

Ruth L. McCollum
Assistant to the President

Ailene J. Bauer
Director of Publications

Lucile B. Stryker
Editor

Earle B. Biesecker [3]
Bursar; Secretary-Treasurer, Retirement Trust

James W. Boise [4]
Assistant Bursar; Assistant Treasurer, Retirement Trust

Kenneth R. Henard [5]
Assistant Bursar; Assistant Treasurer, Retirement Trust

James F. Sullivan
Assistant to the Bursar

Richard F. F. Nichols
Executive Secretary to the Finance Committee

[1] Staff Member, beginning February 1, 1960.
[2] Beginning February 1, 1960.
[3] Retired June 30, 1960.
[4] Bursar; Secretary-Treasurer, Retirement Trust, beginning July 1, 1960.
[5] Appointed July 1, 1960.

RESEARCH ASSOCIATES

of Carnegie Institution of Washington

Walter A. Baade, Bad Salzuflen, Germany[1]
Georges N. Cohen, Institut Pasteur
Louis B. Flexner, University of Pennsylvania
F. T. McClure, Applied Physics Laboratory of The Johns Hopkins University
J. D. McGee, Imperial College of Science and Technology, University of London
Harry E. D. Pollock, Carnegie Institution of Washington
E. E. Salpeter, Cornell University
Edwin M. Shook, University Museum, University of Pennsylvania
P. Swings, Université de Liége
C. E. Tilley, Cambridge University
Evelyn M. Witkin, State University of New York
R. v. d. Woolley, Royal Greenwich Observatory

[1] Died June 25, 1960.

ARTICLES OF INCORPORATION

Public No. 260. An Act to incorporate the Carnegie Institution of Washington

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the persons following, being persons who are now trustees of the Carnegie Institution, namely, Alexander Agassiz, John S. Billings, John L. Cadwalader, Cleveland H. Dodge, William N. Frew, Lyman J. Gage, Daniel C. Gilman, John Hay, Henry L. Higginson, William Wirt Howe, Charles L. Hutchinson, Samuel P. Langley, William Lindsay, Seth Low, Wayne MacVeagh, Darius O. Mills, S. Weir Mitchell, William W. Morrow, Ethan A. Hitchcock, Elihu Root, John C. Spooner, Andrew D. White, Charles D. Walcott, Carroll D. Wright, their associates and successors, duly chosen, are hereby incorporated and declared to be a body corporate by the name of the Carnegie Institution of Washington and by that name shall be known and have perpetual succession, with the powers, limitations, and restrictions herein contained.

Sec. 2. That the objects of the corporation shall be to encourage, in the broadest and most liberal manner, investigation, research, and discovery, and the application of knowledge to the improvement of mankind; and in particular—

(*a*) To conduct, endow, and assist investigation in any department of science, literature, or art, and to this end to cooperate with governments, universities, colleges, technical schools, learned societies, and individuals.

(*b*) To appoint committees of experts to direct special lines of research.

(*c*) To publish and distribute documents.

(*d*) To conduct lectures, hold meetings, and acquire and maintain a library.

(*e*) To purchase such property, real or personal, and construct such building or buildings as may be necessary to carry on the work of the corporation.

(*f*) In general, to do and perform all things necessary to promote the objects of the institution, with full power, however, to the trustees hereinafter appointed and their successors from time to time to modify the conditions and regulations under which the work shall be carried on, so as to secure the application of the funds in the manner best adapted to the conditions of the time, provided that the objects of the corporation shall at all times be among the foregoing or kindred thereto.

Sec. 3. That the direction and management of the affairs of the corporation and the control and disposal of its property and funds shall be vested in a board of trustees, twenty-two in number, to be composed of the following individuals: Alexander Agassiz, John S. Billings, John L. Cadwalader, Cleveland H. Dodge, William N. Frew, Lyman J. Gage, Daniel C. Gilman, John Hay, Henry L. Higginson, William Wirt Howe, Charles L. Hutchinson, *Samuel P. Langley,* William Lindsay, Seth Low, Wayne MacVeagh, Darius O. Mills, S. Weir Mitchell, William W. Morrow, *Ethan A. Hitchcock,* Elihu Root, John C. Spooner, Andrew D. White, Charles D. Walcott, Carroll D. Wright, who shall constitute

the first board of trustees. The board of trustees shall have power from time to time to increase its membership to not more than twenty-seven members. Vacancies occasioned by death, resignation, or otherwise shall be filled by the remaining trustees in such manner as the by-laws shall prescribe; and the persons so elected shall thereupon become trustees and also members of the said corporation. The principal place of business of the said corporation shall be the city of Washington, in the District of Columbia.

Sec. 4. That such board of trustees shall be entitled to take, hold, and administer the securities, funds, and property so transferred by said Andrew Carnegie to the trustees of the Carnegie Institution and such other funds or property as may at any time be given, devised, or bequeathed to them, or to such corporation, for the purposes of the trust; and with full power from time to time to adopt a common seal, to appoint such officers, members of the board of trustees or otherwise, and such employees as may be deemed necessary in carrying on the business of the corporation, at such salaries or with such remuneration as they may deem proper; and with full power to adopt by-laws from time to time and such rules or regulations as may be necessary to secure the safe and convenient transaction of the business of the corporation; and with full power and discretion to deal with and expend the income of the corporation in such manner as in their judgment will best promote the objects herein set forth and in general to have and use all powers and authority necessary to promote such objects and carry out the purposes of the donor. The said trustees shall have further power from time to time to hold as investments the securities hereinabove referred to so transferred by Andrew Carnegie, and any property which has been or may be transferred to them or such corporation by Andrew Carnegie or by any other person, persons, or corporation, and to invest any sums or amounts from time to time in such securities and such form and manner as are permitted to trustees or to charitable or literary corporations for investment, according to the laws of the States of New York, Pennsylvania, or Massachusetts, or in such securities as are authorized for investment by the said deed of trust so executed by Andrew Carnegie, or by any deed of gift or last will and testament to be hereafter made or executed.

Sec. 5. That the said corporation may take and hold any additional donations, grants, devises, or bequests which may be made in further support of the purposes of the said corporation, and may include in the expenses thereof the personal expenses which the trustees may incur in attending meetings or otherwise in carrying out the business of the trust, but the services of the trustees as such shall be gratuitous.

Sec. 6. That as soon as may be possible after the passage of this Act a meeting of the trustees hereinbefore named shall be called by Daniel C. Gilman, John S. Billings, Charles D. Walcott, S. Weir Mitchell, John Hay, Elihu Root, and Carroll D. Wright, or any four of them, at the city of Washington, in the District of Columbia, by notice served in person or by mail addressed to each trustee at his place of residence; and the said trustees, or a majority thereof, being assembled, shall organize and proceed to adopt by-laws, to elect officers and appoint committees, and generally to organize the said corporation; and said trustees herein named, on behalf of the corporation hereby incorporated, shall thereupon receive, take over, and enter into possession, custody, and management of all property, real or personal, of the corporation heretofore known as the Carnegie Institution, incorporated, as hereinbefore set forth under "An Act to establish a Code of Law for the District of Columbia, January fourth, nineteen hundred and two," and to all its rights, contracts,

claims, and property of any kind or nature; and the several officers of such corporation, or any other person having charge of any of the securities, funds, real or personal, books, or property thereof, shall, on demand, deliver the same to the said trustees appointed by this Act or to the persons appointed by them to receive the same; and the trustees of the existing corporation and the trustees herein named shall and may take such other steps as shall be necessary to carry out the purposes of this Act.

Sec. 7. That the rights of the creditors of the said existing corporation known as the Carnegie Institution shall not in any manner be impaired by the passage of this Act, or the transfer of the property hereinbefore mentioned, nor shall any liability or obligation for the payment of any sums due or to become due, or any claim or demand, in any manner or for any cause existing against the said existing corporation, be released or impaired; but such corporation hereby incorporated is declared to succeed to the obligations and liabilities and to be held liable to pay and discharge all of the debts, liabilities, and contracts of the said corporation so existing to the same effect as if such new corporation had itself incurred the obligation or liability to pay such debt or damages, and no such action or proceeding before any court or tribunal shall be deemed to have abated or been discontinued by reason of the passage of this Act.

Sec. 8. That Congress may from time to time alter, repeal, or modify this Act of incorporation, but no contract or individual right made or acquired shall thereby be divested or impaired.

Sec. 9. That this Act shall take effect immediately.

Approved, April 28, 1904

BY-LAWS OF THE INSTITUTION

Adopted December 13, 1904. Amended December 13, 1910, December 13, 1912, December 10, 1937, December 15, 1939, December 13, 1940, December 18, 1942, December 12, 1947, December 10, 1954, October 24, 1957, May 8, 1959, and May 13, 1960.

ARTICLE I

The Trustees

1. The Board of Trustees shall consist of twenty-four members with power to increase its membership to not more than twenty-seven members. The Trustees shall hold office continuously and not for a stated term.

2. In case any Trustee shall fail to attend three successive annual meetings of the Board he shall thereupon cease to be a Trustee.

3. No Trustee shall receive any compensation for his services as such.

4. All vacancies in the Board of Trustees shall be filled by the Trustees by ballot at an annual meeting, but no person shall be declared elected unless he receives the votes of two-thirds of the Trustees present.

ARTICLE II

Officers of the Board

1. The officers of the Board shall be a Chairman of the Board, a Vice-Chairman, and a Secretary, who shall be elected by the Trustees, from the members of the Board, by ballot to serve for a term of three years. All vacancies shall be filled by the Board for the unexpired term; provided, however, that the Executive Committee shall have power to fill a vacancy in the office of Secretary to serve until the next meeting of the Board of Trustees.

2. The Chairman shall preside at all meetings and shall have the usual powers of a presiding officer.

3. The Vice-Chairman, in the absence or disability of the Chairman, shall perform the duties of the Chairman.

4. The Secretary shall issue notices of meetings of the Board, record its transactions, and conduct that part of the correspondence relating to the Board and to his duties.

ARTICLE III

Executive Administration

The President

1. There shall be a President who shall be elected by ballot by, and hold office during the pleasure of, the Board, who shall be the chief executive officer of the Institution. The President, subject to the control of the Board and the Executive Committee, shall have

general charge of all matters of administration and supervision of all arrangements for research and other work undertaken by the Institution or with its funds. He shall prepare and submit to the Board of Trustees and to the Executive Committee plans and suggestions for the work of the Institution, shall conduct its general correspondence and the correspondence with applicants for grants and with the special advisers of the Committee, and shall present his recommendations in each case to the Executive Committee for decision. All proposals and requests for grants shall be referred to the President for consideration and report. He shall have power to remove, appoint, and, within the scope of funds made available by the Trustees, provide for compensation of subordinate employees and to fix the compensation of such employees within the limits of a maximum rate of compensation to be established from time to time by the Executive Committee. He shall be *ex officio* a member of the Executive Committee.

2. He shall be the legal custodian of the seal and of all property of the Institution whose custody is not otherwise provided for. He shall sign and execute on behalf of the corporation all contracts and instruments necessary in authorized administrative and research matters and affix the corporate seal thereto when necessary, and may delegate the performance of such acts and other administrative duties in his absence to the Executive Officer. He may execute all other contracts, deeds, and instruments on behalf of the corporation and affix the seal thereto when expressly authorized by the Board of Trustees or Executive Committee. He may, within the limits of his own authorization, delegate to the Executive Officer authority to act as custodian of and affix the corporate seal. He shall be responsible for the expenditure and disbursement of all funds of the Institution in accordance with the directions of the Board and of the Executive Committee, and shall keep accurate accounts of all receipts and disbursements. Following approval by the Executive Committee he shall transmit to the Board of Trustees before its annual meeting a written report of the operations and business of the Institution for the preceding fiscal year with his recommendations for work and appropriations for the succeeding fiscal year.

3. He shall attend all meetings of the Board of Trustees.

4. There shall be an officer designated Executive Officer who shall be appointed by and hold office at the pleasure of the President, subject to the approval of the Executive Committee. His duties shall be to assist and act for the President as the latter may duly authorize and direct.

5. The President shall retire from office at the end of the fiscal year in which he becomes sixty-five years of age.

ARTICLE IV

Meetings

1. The annual meeting of the Board of Trustees shall be held in the City of Washington, in the District of Columbia, in May of each year on a date set by order of the Executive Committee, unless the date and place of meeting are otherwise set by order of the Executive Committee.

2. Special meetings of the Board may be called by the Executive Committee by notice served personally upon, or mailed to the usual address of, each Trustee twenty days prior to the meeting.

3. Special meetings shall, moreover, be called in the same manner by the Chairman upon the written request of seven members of the Board.

ARTICLE V

Committees

1. There shall be the following standing Committees, *viz.* an Executive Committee, a Finance Committee, an Auditing Committee, a Nominating Committee, and a Retirement Committee.

2. All vacancies occurring in the Executive Committee, the Finance Committee, the Auditing Committee, the Nominating Committee, and the Retirement Committee shall be filled by the Trustees at the next regular meeting. In case of vacancy in the Finance Committee, the Auditing Committee, the Nominating Committee, or the Retirement Committee, upon request of the remaining members of such committee, the Executive Committee may fill such vacancy by appointment until the next meeting of the Board of Trustees.

3. The terms of all officers and of all members of committees, as provided for herein, shall continue until their successors are elected or appointed.

Executive Committee

4. The Executive Committee shall consist of the Chairman, Vice-Chairman, and Secretary of the Board of Trustees and the President of the Institution *ex officio* and, in addition, five trustees to be elected by the Board by ballot for a term of three years, who shall be eligible for re-election. Any member elected to fill a vacancy shall serve for the remainder of his predecessor's term.

5. The Executive Committee shall, when the Board is not in session and has not given specific directions, have general control of the administration of the affairs of the corporation and general supervision of all arrangements for administration, research, and other matters undertaken or promoted by the Institution. It shall also submit to the Board of Trustees a printed or typewritten report of each of its meetings, and at the annual meeting shall submit to the Board a report for publication.

6. The Executive Committee shall have power to authorize the purchase, sale, exchange, or transfer of real estate.

Finance Committee

7. The Finance Committee shall consist of not less than five and not more than six members to be elected by the Board of Trustees by ballot for a term of three years, who shall be eligible for re-election.

8. The Finance Committee shall have custody of the securities of the corporation and general charge of its investments and invested funds, including its investments and invested funds as trustee of any retirement plan for the Institution's staff members and employees, and shall care for and dispose of the same subject to the directions of the Board of Trustees. It shall have power to authorize the purchase, sale, exchange, or transfer of securities and to delegate this power. It shall consider and recommend to the Board from time to time such measures as in its opinion will promote the financial interests of the Institution and of the trust fund under any retirement plan for the Institution's staff members and employees, and shall make a report at each meeting of the Board.

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Auditing Committee

9. The Auditing Committee shall consist of three members to be elected by the Board of Trustees by ballot for a term of three years.

10. Before each annual meeting of the Board of Trustees, the Auditing Committee shall cause the accounts of the Institution for the preceding fiscal year to be audited by public accountants. The accountants shall report to the Committee, and the Committee shall present said report at the ensuing annual meeting of the Board with such recommendations as the Committee may deem appropriate.

Nominating Committee

11. The Nominating Committee shall consist of the Chairman of the Board of Trustees *ex officio* and, in addition, three trustees to be elected by the Board by ballot for a term of three years, who shall not be eligible for re-election until after the lapse of one year. Any member elected to fill a vacancy shall serve for the remainder of his predecessor's term, provided that of the Nominating Committee first elected after adoption of this By-Law one member shall serve for one year, one member shall serve for two years, and one member shall serve for three years, the Committee to determine the respective terms by lot.

12. Sixty days prior to an annual meeting of the Board the Nominating Committee shall notify the Trustees by mail of the vacancies to be filled in membership of the Board. Each Trustee may submit nominations for such vacancies. Nominations so submitted shall be considered by the Nominating Committee, and ten days prior to the annual meeting the Nominating Committee shall submit to members of the Board by mail a list of the persons so nominated, with its recommendations for filling existing vacancies on the Board and its Standing Committees. No other nominations shall be received by the Board at the annual meeting except with the unanimous consent of the Trustees present.

Retirement Committee

13. The Retirement Committee shall consist of three members to be elected by the Board of Trustees by ballot for a term of three years, who shall be eligible for re-election, and the Chairman of the Finance Committee *ex officio*. Any member elected to fill a vacancy shall serve for the remainder of his predecessor's term.

14. The Retirement Committee shall, subject to the directions of the Board of Trustees, be responsible for the maintenance of a retirement plan for staff members and employees of the Institution and act for the Institution in its capacity as trustee under any such plan, except that any matter relating to investments under any such plan shall be the responsibility of the Finance Committee subject to the directions of the Board of Trustees. The Committee shall submit a report to the Board at the annual meeting of the Board.

ARTICLE VI

Financial Administration

1. No expenditure shall be authorized or made except in pursuance of a previous appropriation by the Board of Trustees, or as provided in Article V, paragraph 8, hereof.

2. The fiscal year of the Institution shall commence on the first day of July in each year.

3. The Executive Committee shall submit to the annual meeting of the Board a full statement of the finances and work of the Institution for the preceding fiscal year and a detailed estimate of the expenditures of the succeeding fiscal year.

4. The Board of Trustees, at the annual meeting in each year, shall make general appropriations for the ensuing fiscal year; but nothing contained herein shall prevent the Board of Trustees from making special appropriations at any meeting.

5. The Executive Committee shall have general charge and control of all appropriations made by the Board. Following the annual meeting, the Executive Committee may allocate these appropriations for the succeeding fiscal year. The Committee shall have full authority to reallocate available funds, as needed, and to transfer balances.

6. The securities of the Institution and evidences of property, and funds invested and to be invested, shall be deposited in such safe depository or in the custody of such trust company and under such safeguards as the Finance Committee shall designate, subject to directions of the Board of Trustees. Income of the Institution available for expenditure shall be deposited in such banks or depositories as may from time to time be designated by the Executive Committee.

7. Any trust company entrusted with the custody of securities by the Finance Committee may, by resolution of the Board of Trustees, be made Fiscal Agent of the Institution, upon an agreed compensation, for the transaction of the business coming within the authority of the Finance Committee.

ARTICLE VII

Amendment of By-Laws

1. These by-laws may be amended at any annual or special meeting of the Board of Trustees by a two-thirds vote of the members present, provided written notice of the proposed amendment shall have been served personally upon, or mailed to the usual address of, each member of the Board twenty days prior to the meeting.

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~~President~~

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